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THE EFFECT OF AQUEOUS SOLUTIONS UPON THE GERMINATION OF FUNGUS SPORES.[1]

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OBJECT.

THE primary object in the work here related was to establish with some degree of accuracy the strengths of various solutions which are necessary to prevent the growth of fungus spores.

The bearing of this question upon the relation of a fungicide to its efficiency is apparent, and from the wide use of these compounds it seems important that all knowledge possible should be gained regarding the principles underlying their action.

Incidentally, new evidence bearing upon the theory of the hydrolytic dissociation of the molecule is adduced; also facts which may throw some light upon the structure of the cell wall

PRELIMINARY.

Before work bearing results could be practically undertaken, it became necessary to select the best manner of working, and the materials to use, and to become familiar with the sources of error most common.

[1] Contributions from the Hull Botanical Laboratory. XI.

After various means of culture had been tried, the van Tieghem hanging drop proved the most satisfactory.

In the selection of material such fungi were chosen as could be obtained in abundance, could be easily kept in stock culture, were not liable to become seriously impure, and, of most importance, such as would uniformly grow in the kind of culture medium used.

Botrytis vulgaris Fr., *Macrosporium* (*sp.* ?) from the fruit of *Datura Tatula*, *Glœosporium Musarum* C. & M., and *Uromyces caryophyllinus* (Schrank) Schr., were selected. *Penicillium crustaceum* (Linn.) Fries was useful in tube cultures.

Many other fungi were tried but presented disadvantages which prohibited their use.

Several hundred cultures were made to ascertain whether there was any toxic effect from the cells, cement, or oil used to seal the cell, and to note whether or not nourishing materials were useful in the solution.

METHODS.

The cultures were made in hanging drop in van Tieghem cells used in the usual manner with vaseline as an adhesive. It was not found necessary to place them in a moist chamber, as they did not dry if carefully sealed. Cultures were uniformly examined about twenty-four hours after their preparation and every time that a series of cultures was made, a series of check cultures in distilled water was prepared. In every case where the checks failed to grow, all negative results were discarded The cells themselves were frequently thoroughly cleansed and the cover glasses were carefully wiped each time before using washed in alcohol and wiped again.

In order to facilitate the making of cultures a tube was bent as shown in the figure on opposite page. By slightly raising the long end the liquid rises in the short end and a hanging drop of any desired size is readily placed on the cover glass.

This tube was washed, then rinsed with the solution under observation, then filled with that solution. This and all other

tubes and bottles used were, of course, very thoroughly washed before introducing another chemical or one of different strength. The drop being upon the cover glass, a clean teasing needle or platinum needle was touched to the stock culture, and then to the hanging drop. Before using this needle with another chemical it was washed. Sterilization was nowhere necessary, as the culture was to be of such short duration that bacteria or other fungi did not develop.

The cultures of *Penicillium crustaceum* (Linn.) Fries were made otherwise. A small piece of bread $2 \times 1 \times 1^{cm}$ was soaked in the solution under experimentation, then placed in a 15^{cm} test tube where it was about three quarters immersed in the solution. It was then inoculated with the Penicillium, evaporation being prevented by a stopper to the tube.

Readings were made with this fungus when the checks had begun to grow well.

In order to insure that a proper planting had been made, and to be sure that no spores had been germinated previous to being placed in the solution, each slide was microscopically examined before placing away.

The series of cultures being made, the slides bearing them were placed away in a thermostat on a metallic slide holder.

SOLUTIONS.

Inasmuch as the object of the work was to investigate the effect of the salts upon the growth of the fungus, it was deemed advisable to prepare solutions the composition of which should be based upon their molecular weight rather than upon a percentage basis. To do this the molecular weight of the salt, base, or acid was estimated, and this weight taken in grams was dissolved in one liter of water. Such a solution is designated throughout this article as a *normal solution*. Thus, potassium

hydrate has the formula KOH. K, O and H have respectively the atomic weights 38.85, 15.88 and 1. Therefore the molecular weight of KOH is 55.73. Then 55.73^{gm} of potassium hydrate dissolved in one liter of water constitutes a normal solution of potassium hydrate.

It will be readily seen then that, the work being accurately done and the molecular formulæ being correct, a normal solution of any substance will contain as many molecules per cubic centimeter as a normal solution of any other substance.

In a few cases solutions of greater than normal strength were used, but generally, if the substance did not prevent growth when in one-tenth of normal strength, the substance was considered non-poisonous and was not experimented with further.

Starting with a normal solution, dilutions were easily made till such strength was reached that the spores would germinate The various strengths used are designated as fractions of normal Thus $\frac{n}{800}$ signifies a solution of one eight-hundredth normal, a strength which could be prepared by taking one cubic centimeter of normal solution and diluting it to 800^{cc}. Ten cubic centimeters of $\frac{n}{800}$ diluted to 80^{cc} would furnish $\frac{n}{6400}$, etc.

The atomic weights used are those given by Roscoe and Schorlemmer.[2]

TABULATION AND DISCUSSION.

In tables I–XVI appears a record of the cultures made, more than 1500 in all, each culture bearing from fifty to a few thousand spores. The fraction shows the strength of solution used, and the figure to the left of the fraction shows the number of times this strength was tried. If the fungus grew, the strength in which it grew appears in the corresponding column. Those strengths in which it failed are to be found in the column headed Failed. Reference to a footnote indicates some peculiarity regarding the culture, which will be found explained in the note. The numbers used in these footnotes are original numbers of the cultures.

[2] Treatise on Chemistry 1 : 52. 1895 [ed. 3].

TABLE I.

MERCURIC CHLORID.

Botrytis		Macrosporium		Penicillium		Uromyces	
Grew	Failed	Grew	Failed	Grew	Failed	Grew	Failed
$1\frac{n}{51200}$ *	$4\frac{n}{12800}$	$3\frac{n}{819200}$	$1\frac{n}{819200}$	$2\frac{n}{25600}$	$2\frac{n}{3200}$	$2\frac{n}{204800}$	$6\frac{n}{6400}$
$3\frac{n}{102400}$	$5\frac{n}{25600}$	$5\frac{n}{409600}$ †	$3\frac{n}{409600}$	$2\frac{n}{12800}$		$1\frac{n}{51200}$	
$8\frac{n}{204800}$	$2\frac{n}{51200}$	$4\frac{n}{204800}$ ‡	$6\frac{n}{204800}$	$2\frac{n}{6400}$		$3\frac{n}{25600}$	
	$1\frac{n}{102400}$	$1\frac{n}{102400}$	$3\frac{n}{102400}$	$6\frac{n}{3200}$ §		$4\frac{n}{12800}$ ¶	
			$4\frac{n}{51200}$				
			$4\frac{n}{25600}$				

* No. 436. Growth scattered.
† No. 157. Four cultures normal and one slight but uniform.
‡ No. 156. One culture, slight but uniform.
§ No. 927. Slight growth; was dry.
¶ No. 200. Scattered growth.

Mercuric chlorid.—Thus we see that Botrytis grew in $\frac{n}{204800}$ in eight different cultures, and there is no evidence that this strength injures it. In $\frac{n}{102400}$ three cultures grew normally and one failed to grow. The growth here may be considered as normal. In $\frac{n}{51200}$, twice as strong as the last, growth was poor in one culture, two failed utterly, and the strength necessary to prevent germination is evidently reached. Five cultures of twice this strength or $\frac{n}{25600}$ were tried, but all failed to germinate.

So it can be concluded that the strength which prevents most spores from growing is $\frac{n}{51200}$, and that $\frac{n}{25600}$ is a sure preventive. Then the range from sure prevention of growth to a normal growth is from $\frac{n}{25600}$ to $\frac{n}{102400}$.

With Macrosporium the growth was normal for $\frac{n}{819200}$, while $\frac{n}{409600}$ and $\frac{n}{204800}$ grew but gave evidence of injury, and $\frac{n}{51200}$ proved a sure preventive. With Penicillium, starting with

as weak as $\frac{n}{25600}$, the growth was normal, in as strong as $\frac{n}{3200}$ a killing strength was not reached.

Uromyces, from a generalization made in my notebook, grew normally in $\frac{n}{25600}$, not quite as well in $\frac{n}{12800}$, and is prevented by $\frac{n}{6400}$ except in very rare cases, where a single spore grows.

TABLE II.

POTASSIUM CYANID.

Glœosporium		Macrosporium		Penicillium		Uromyces	
Grew	Failed	Grew	Failed	Grew	Failed	Grew	Failed
$2\frac{n}{6400}$	$1\frac{n}{800}$	$2\frac{n}{25600}$	$1\frac{n}{400}$	$2\frac{n}{12800}$	$2\frac{n}{100}$	$2\frac{n}{25600}$	$2\frac{n}{800}$
$2\frac{n}{3200}$		$2\frac{n}{800}$	$2\frac{n}{50}$	$2\frac{n}{800}$		$2\frac{n}{6400}$	$3\frac{n}{200}$ †
$1\frac{n}{800}$		$1\frac{n}{400}$	$1\frac{n}{50}$ *	$2\frac{n}{400}$		$2\frac{n}{3200}$	$7\frac{n}{100}$
$2\frac{n}{400}$		$2\frac{n}{100}$		$2\frac{n}{200}$		$4\frac{n}{800}$	
						$1\frac{n}{400}$	
						$2\frac{n}{100}$	

* No. 1369. Some grew poorly.

† No. 1363. Nearly all grew to about half normal size.

Potassium cyanid.—Potassium cyanid was tried upon Glœosporium and other fungi, and, notwithstanding its great toxic action upon animal organisms, proved comparatively harmless to the spores. Starting with $\frac{n}{6400}$ on Glœosporium, successively stronger solutions were tried till $\frac{n}{400}$ was reached without preventing growth. No stronger solutions were tried.

Macrosporium with potassium cyanid was started at $\frac{n}{25600}$, and successively stronger solutions taken till $\frac{n}{50}$ was reached. In this strength one culture grew poorly and two failed, so that the fatal strength was evidently reached. With Penicillium $\frac{n}{100}$ proved fatal. Uromyces grew normally till a strength of $\frac{n}{200}$ was reached. In this the growth was much stunted in one culture,

and two failed. In $\frac{n}{1000}$ two cultures grew somewhat, while seven failed utterly.

The unexpectedly low toxic action of potassium cyanid is puzzling, especially as other experimenters[3] upon spermatophytes find its toxic action about one-half that of mercuric chlorid.

It is evident that the action of this salt upon fungi is not as vigorously toxic as upon higher plants and animals.

TABLE III.

HYDROCHLORIC ACID.

Glœosporium		Macrosporium		Penicillium		Uromyces	
Grew	Failed	Grew	Failed	Grew	Failed	Grew	Failed
$3\frac{n}{800}$		$2\frac{n}{6400}$	$1\frac{n}{200}$	$1\frac{n}{6400}$	$1\frac{n}{6400}$	$2\frac{n}{3200}$	$2\frac{n}{800}$
$2\frac{n}{400}$		$2\frac{n}{400}$	$3\frac{n}{50}$	$2\frac{n}{400}$		$2\frac{n}{800}$	$1\frac{n}{400}$
$1\frac{n}{200}$		$1\frac{n}{200}$		$2\frac{n}{200}$		$1\frac{n}{400}$	$2\frac{n}{200}$
$1\frac{n}{100}$		$4\frac{n}{100}$		$2\frac{n}{100}$		$2\frac{n}{100}$	$2\frac{n}{100}$
		$2\frac{n}{50}$ *		$2\frac{n}{50}$			$4\frac{n}{50}$ †

*No. 1376. Not quite normal.

†No. 1358. Stunted.—1359. About 1 in 200 grew.

Hydrochloric and sulfuric acids.—These acids have about an equal status in the results of the work upon Glœosporium. Starting with a solution of $\frac{n}{800}$ the spores grew normally. Gradually stronger solutions were taken till growth was evident in $\frac{n}{1000}$ with HCl, but H_2SO_4 of this strength weakened the growth perceptibly. Glœosporium here became irregular in its behavior, and the killing point was not reached. The secondary spores so common in this genus were produced, however, in

[3] KAHLENBERG and TRUE, On the toxic action of dissolved salts and their electrolytic dissociation. BOT. GAZ. **22**: 81.

F. D. HEALD, On the toxic effect of dilute solutions of acids and salts upon plants. BOT. GAZ. **22**: 125.

unusual abundance in these solutions, and may have been an indication of injurious action. The fact may also be significant that abnormal and distorted mycelium more frequently resulted than in ordinary nutrient solution.

TABLE IV.

SULFURIC ACID.

Glœosporium		Macrosporium		Penicillium		Uromyces	
Grew	Failed	Grew	Failed	Grew	Failed	Grew	Failed
3 $\frac{n}{800}$ *	1 $\frac{n}{800}$	3 $\frac{n}{800}$	1 $\frac{n}{800}$	2 $\frac{n}{6400}$		2 $\frac{n}{800}$	1 $\frac{n}{800}$
2 $\frac{n}{400}$		2 $\frac{n}{400}$	2 $\frac{n}{100}$	2 $\frac{n}{400}$		1 $\frac{n}{400}$	1 $\frac{n}{400}$
2 $\frac{n}{200}$		2 $\frac{n}{200}$ †	2 $\frac{n}{50}$	2 $\frac{n}{200}$		1 $\frac{n}{200}$	1 $\frac{n}{200}$
1 $\frac{n}{100}$		2 $\frac{n}{100}$		2 $\frac{n}{100}$		1 $\frac{n}{100}$	6 $\frac{n}{100}$
		2 $\frac{n}{50}$		2 $\frac{n}{50}$			

* No. 1338. Poorly.

† No. 1094. Stunted.

‡ No. 1028. Ten in 100 grew poorly.

With Macrosporium and Penicillium neither acid prevented growth at $\frac{n}{50}$. Uromyces was exceedingly variable in its behavior with these acids, and the results, as far as they can be interpreted, seem to show H_2SO_4 to be a trifle more toxic. The killing point of HCl apparently is $\frac{n}{50}$, while for H_2SO_4 it is $\frac{n}{100}$.

Alcohol.—Glœosporium germinated normally in alcohol of semi-normal strength. Macrosporium even grew in five times normal strength, while Penicillium grew in semi-normal, but failed in normal. Uromyces grew in five times normal. Stronger solutions were not tried, owing to the inability to secure hanging drops in stronger solutions. The low toxic power might be sought here in volatility, but this seems not to be the cause, as it was evident that the Uromyces, Botrytis, and Macrosporium

were stimulated by the alcohol. More spores grew, and they grew far more luxuriantly than in water.

TABLE V.

ALCOHOL.

Botrytis		Macrosporium		Penicillium		Uromyces	
Grew	Failed	Grew	Failed	Grew	Failed	Grew	Failed
$2\frac{n}{10}$		$2\frac{n}{10}$		$2\frac{n}{5}$	$4\frac{2n}{1}$	$2\frac{n}{10}$	
$2\frac{n}{1}$		$2\frac{n}{1}$		$2\frac{n}{2}$	$2\frac{n}{1}$	$2\frac{n}{1}$ *	
		$2\frac{5n}{1}$				$2\frac{5n}{1}$	

*No. 480. Much knotted and distorted.

TABLE VI.

COPPER SULFATE.

Botrytis		Macrosporium		Penicillium		Uromyces	
Grew	Failed	Grew	Failed	Grew	Failed	Grew	Failed
$2\frac{n}{12800}$	$1\frac{n}{6400}$	$1\frac{n}{12800}$	$6\frac{n}{6400}$	$2\frac{n}{6400}$	$1\frac{n}{800}$	$2\frac{n}{12800}$	$3\frac{n}{6400}$
$5\frac{n}{6400}$ *	$2\frac{n}{3200}$	$2\frac{n}{6400}$ †	$2\frac{n}{3200}$	$2\frac{n}{3200}$	$2\frac{n}{200}$	$5\frac{n}{6400}$ ‡	$2\frac{n}{3200}$ §
	$2\frac{n}{100}$		$2\frac{n}{100}$	$2\frac{n}{1600}$			$1\frac{n}{100}$ ¶
				$3\frac{n}{800}$			
				$2\frac{n}{400}$			

*No. 274. Scattered.
†No. 377. Grew slightly.
‡No. 706. One culture stunted.
§No. 700. One in 300 grew.
¶No. 290. A few grew in one culture.

Copper sulfate.—Botrytis failed in $\frac{n}{3200}$, grew poorly in $\frac{n}{6400}$, and normally in $\frac{n}{12800}$. Macrosporium behaved in a similar manner, but was more injured by $\frac{n}{6400}$.

TABLE VII.

COPPER NITRATE.

Botrytis		Macrosporium		Penicillium		Uromyces	
Grew	Failed	Grew	Failed	Grew	Failed	Grew	Failed
$2\frac{n}{6400}$	$2\frac{n}{3200}$	$1\frac{n}{6400}$	$2\frac{n}{100}$	$2\frac{n}{6400}$	$2\frac{n}{200}$ *	$2\frac{n}{6400}$	$2\frac{n}{3200}$
	$2\frac{n}{100}$	$1\frac{n}{3200}$		$2\frac{n}{3200}$			$2\frac{n}{100}$
				$2\frac{n}{800}$			
				$2\frac{n}{400}$			

* No. 956. Grew on dry part only in one culture.

TABLE VIII.

COPPER ACETATE.

Botrytis		Macrosporium		Penicillium		Uromyces	
Grew	Failed	Grew	Failed	Grew	Failed	Grew	Failed
$2\frac{n}{6400}$	$2\frac{n}{3200}$	$2\frac{n}{6400}$	$3\frac{n}{3200}$	$2\frac{n}{3200}$	$2\frac{n}{800}$	$2\frac{n}{6400}$	$6\frac{n}{1600}$ *
		$1\frac{n}{3200}$	$2\frac{n}{1000}$	$2\frac{n}{1600}$		$4\frac{n}{3200}$	$3\frac{n}{800}$ †
							$4\frac{n}{400}$ ‡
							$4\frac{n}{200}$

* No. 524. Twenty per 100 grew.—No. 525. Eighteen in 150 grew.
† No. 551. Five in 100 grew.—No. 552. A few in a bunch grew.
‡ No. 586. Six in 100 grew.—No. 587. Four in 100 grew.

Copper nitrate.—Botrytis grew in $\frac{n}{6400}$ and failed in $\frac{n}{3200}$. Macrosporium grew in $\frac{n}{3200}$. Penicillium grew in $\frac{n}{400}$, and in $\frac{n}{200}$ one culture became dry and grew at the dry portion, but the culture which remained moist showed no growth. Uromyces grew in $\frac{n}{6400}$, but failed in $\frac{n}{3200}$.

Here it first became evident that Uromyces, as the toxic solution becomes stronger, does not diminish in vigor of growth, but does diminish in the number of germinating spores.

Copper acetate.—Botrytis grew in $\frac{n}{6400}$ and failed in $\frac{n}{3200}$. Macrosporium grew in $\frac{n}{6400}$ and failed in $\frac{n}{3200}$. Penicillium grew in $\frac{n}{1600}$ and failed in $\frac{n}{800}$. Uromyces was a practical failure in $\frac{n}{800}$ or stronger, but some spores grew poorly in $\frac{n}{400}$, and, on the other hand, were much injured by $\frac{n}{3200}$. There was no growth it $\frac{n}{200}$, which was tried four times.

TABLE IX.

COPPER CHLORID.

Glœosporium		Macrosporium		Penicillium		Uromyces	
Grew	Failed	Grew	Failed	Grew	Failed	Grew	Failed
1 $\frac{n}{12800}$	2 $\frac{n}{6400}$		2 $\frac{n}{3200}$	2 $\frac{n}{6400}$	2 $\frac{n}{200}$	1 $\frac{n}{6400}$	4 $\frac{n}{3200}$ *
	2 $\frac{n}{3200}$			2 $\frac{n}{3200}$			4 $\frac{n}{1600}$ †
	2 $\frac{n}{1600}$			2 $\frac{n}{1600}$			
				2 $\frac{n}{800}$			
				2 $\frac{n}{400}$			

*No. 758. Four in 100 grew.—No. 759. One half usual number grew.
†No. 757. Three in 200 grew.

Copper chlorid.—This was tried upon Glœosporium. In $\frac{n}{12800}$ it grew, while in $\frac{n}{6400}$ it failed. Macrosporium was tried with only one strength, $\frac{n}{3200}$. It failed to grow. Penicillium grew in $\frac{n}{400}$ and weaker, and failed in $\frac{n}{200}$. Uromyces in $\frac{n}{6400}$ grew; in $\frac{n}{3200}$ three grew very poorly and one failed. This is evidently a killing strength.

Potassium permanganate.—The killing strength of this chemical was determined with much accuracy, and in experimenta-

tion presented interesting phenomena. In strong solutions, that is $\frac{n}{100}$ or stronger, it stained the protoplasm and prevented growth. With Glœosporium $\frac{n}{800}$ prevented growth and $\frac{n}{1600}$ allowed it. At this strength the protoplasm was barely tinted.

That strong solutions are withstood by Penicillium may be partly explained by the decompositions due to the organic matter present; but this can only slightly reduce the amount of the salt present.

Uromyces grew normally in $\frac{n}{400}$, and there was practically no growth in $\frac{n}{300}$ or stronger, although in culture 749 one spore, standing unprotected in the hanging drop and to all appearances in the same conditions as any of the others in the drop, grew normally, although the protoplasmic contents of its germ tube were colored strongly. This apparently perfectly normal growth, while the surrounding spores remained completely undeveloped, may be taken as almost typical of the behavior of the uredospores of *Uromyces caryophyllinus* when in highly poisonous solutions.

TABLE X.

POTASSIUM PERMANGANATE.

Glœosporium		Macrosporium		Penicillium		Uromyces	
Grew	Failed	Grew	Failed	Grew	Failed	Grew	Failed
$2\ \frac{n}{1600}$	$2\ \frac{n}{800}$			$2\ \frac{n}{20}$		$4\ \frac{n}{400}$	$2\ \frac{n}{200}$
	$4\ \frac{n}{400}$			$2\ \frac{n}{10}$			$2\ \frac{n}{100}$ *
	$2\ \frac{n}{200}$						

*No. 749. One spore grew well.

Sodium chlorid.—This proved practically non-toxic. With Botrytis a semi-normal solution did not prevent normal germination. Macrosporium grew in a normal solution. With these two fungi a killing strength was not obtained.

TABLE XI.

SODIUM CHLORID.

Glœosporium		Macrosporium		Penicillium		Uromyces	
Grew	Failed	Grew	Failed	Grew	Failed	Grew	Failed
$4\ \frac{n}{6400}$		$4\ \frac{n}{3200}$		$3\ \frac{n}{50}$		$2\ \frac{n}{3200}$ †	$5\ \frac{n}{2}$ ‡
$2\ \frac{n}{1600}$ *		$2\ \frac{n}{100}$		$2\ \frac{n}{2}$		$2\ \frac{n}{100}$	$2\ \frac{n}{1}$
$4\ \frac{n}{100}$		$2\ \frac{n}{2}$		$2\ \frac{2n}{1}$			$4\ \frac{2n}{1}$
$2\ \frac{n}{1}$		$1\ \frac{n}{1}$					$2\ \frac{4n}{1}$

*No. 25. Apparently stimulated. † No. 146. Apparently stimulated.

‡ No. 446. In one culture only 3 per cent. grew.

TABLE XII.

POTASSIUM CHROMATE.

Botrytis		Macrosporium		Penicillium		Uromyces	
Grew	Failed	Grew	Failed	Grew	Failed	Grew	Failed
	$1\ \frac{n}{640}$	$2\ \frac{n}{640}$ †	$1\ \frac{n}{320}$		$2\ \frac{n}{640}$	$2\ \frac{n}{320}$	$3\ \frac{n}{40}$ ¶
	$2\ \frac{n}{320}$	$1\ \frac{n}{320}$	$2\ \frac{n}{10}$		$2\ \frac{n}{320}$	$4\ \frac{n}{160}$ ‡	$2\ \frac{n}{10}$
	$2\ \frac{n}{40}$	$1\ \frac{n}{40}$ *			$2\ \frac{n}{160}$	$3\ \frac{n}{80}$ §	
	$2\ \frac{n}{10}$				$2\ \frac{n}{80}$		
					$2\ \frac{n}{10}$		

*No. 539. Growth slight. † No. 652. Growth slight.

‡ No. 611. Many failed, but those which grew were normal.

§ Nos. 602, 604. Nearly every spore grew, but the tubes were about half the usual length, and the protoplasm was granular and finally plasmolyzed.

¶ Nos. 640, 641. One in 200 grew.—No. 642. Two in 200 grew.

Potassium chromate.—Uromyces failed in three cultures $\frac{n}{40}$. One culture in $\frac{n}{40}$ had one spore grow, but this grew with

remarkable vigor, producing a tube fully twice the usual length, while in two other cultures of the same strength respectively one in 100 and two in 200 grew. The fatal strength here is thus evidently $\frac{n}{40}$, while $\frac{n}{160}$ has an appreciable toxic action, and $\frac{n}{80}$ is strongly toxic.

TABLE XIII.

POTASSIUM BICHROMATE.

Botrytis		Macrosporium		Penicillium		Uromyces	
Grew	Failed	Grew	Failed	Grew	Failed	Grew	Failed
	$2\ \frac{n}{1280}$	$2\ \frac{n}{3200}$ *	$2\ \frac{n}{1280}$		$3\ \frac{n}{1600}$	$2\ \frac{n}{3200}$ †	$2\ \frac{n}{1280}$
	$2\ \frac{n}{640}$		$2\ \frac{n}{640}$		$2\ \frac{n}{800}$	$3\ \frac{n}{640}$ ‡	$1\ \frac{n}{640}$
	$2\ \frac{n}{320}$		$2\ \frac{n}{320}$		$2\ \frac{n}{160}$		$2\ \frac{n}{320}$
	$2\ \frac{n}{160}$		$2\ \frac{n}{160}$		$2\ \frac{n}{10}$		$2\ \frac{n}{160}$
	$2\ \frac{n}{40}$		$2\ \frac{n}{40}$				$2\ \frac{n}{40}$
	$2\ \frac{n}{10}$		$2\ \frac{n}{10}$				$4\ \frac{n}{10}$

* No. 715. Grew poorly.

† Nos. 712, 713. One in seventy-five grew normally.

‡ No. 634. Two spores grew well.—No. 635. One in eighty grew.—No. 636 Three in seventy-five grew.

Potassium bichromate.—This would not allow the germination of Botrytis spores when of $\frac{n}{1280}$ strength. No weaker was tried. Macrosporium would not grow in $\frac{n}{1280}$, and in the next weaker tried, $\frac{n}{3200}$, it grew poorly. Penicillium failed to grow in $\frac{n}{1600}$, and weaker were not tried. Uromyces spores were nearly all killed by $\frac{n}{640}$, would not grow in stronger, and were injured by even weaker. Penicillium grew in as strong as double normal, and killing strength was not reached. Uromyces was prevented almost completely by $\frac{n}{2}$, and stronger solutions absolutely prohibited germination. Weak solutions, such as $\frac{n}{3200}$, seemed to stimulate the early growth somewhat.

TABLE XIV.

AMMONIUM NITRATE.

Botrytis		Penicillium		Uromyces	
Grew	Failed	Grew	Failed	Grew	Failed
$2\frac{n}{4}$ *	$2\frac{n}{2}$	$2\frac{n}{2}$		$1\frac{n}{4}$	$2\frac{n}{2}$

* No. 654. Growth slight.

TABLE XV.

POTASSIUM HYDROXID.

Macrosporium		Penicillium		Uromyces	
Grew	Failed	Grew	Failed	Grew	Failed
$4\frac{n}{200}$		$2\frac{n}{50}$	$1\frac{n}{20}$ *	$2\frac{n}{200}$	$2\frac{n}{200}$
$2\frac{n}{100}$		$1\frac{n}{20}$ †	$2\frac{n}{40}$	$1\frac{n}{100}$	

SODIUM HYDROXID.

$2\frac{n}{200}$		$2\frac{n}{50}$	$2\frac{n}{40}$	$1\frac{n}{200}$	
$2\frac{n}{100}$			$2\frac{n}{20}$	$2\frac{n}{100}$	

AMMONIUM HYDROXID.

		$1\frac{n}{28}$	$2\frac{n}{2.78}$		
			$2\frac{n}{5.56}$		
			$2\frac{n}{13.7}$		
			$1\frac{n}{28}$		

* No. 825. Grew not at all.
† No. 824. Grew luxuriantly.

Ammonium nitrate.—This permitted the growth of Botrytis in $\frac{n}{4}$ but not in $\frac{n}{2}$. Penicillium grew in $\frac{n}{2}$. Uromyces was prevented by $\frac{n}{2}$, but grew in $\frac{n}{4}$.

Potassium, sodium, and ammonium hydroxids.— Macrosporium gave identical results with the first two of these chemicals and a killing strength was not reached at $\frac{n}{100}$. Stronger solutions could not be tried in drop culture. With Penicillium the fatal strength may be considered as $\frac{n}{40}$ for sodium and potassium hydroxids. There is an apparent anomaly in the fact that in one tube the fungus grew finely in KOH $\frac{n}{20}$, while its mate failed utterly. This can be explained on the assumption that one spore or more found a lodging place in a fragment of unsaturated bread, and thus attained a sufficient protection and

TABLE XVI.

POTASSIUM IODID.

Botrytis		Macrosporium		Penicillium		Uromyces	
Grew	Failed	Grew	Failed	Grew	Failed	Grew	Failed
1 $\frac{n}{20}$		2 $\frac{n}{50}$		2 $\frac{n}{10}$		2 $\frac{n}{50}$	
2 $\frac{n}{50}$		1 $\frac{n}{40}$				2 $\frac{n}{20}$	
		1 $\frac{n}{20}$					

POTASSIUM BROMID.

2 $\frac{n}{20}$		2 $\frac{n}{20}$		2 $\frac{n}{10}$		2 $\frac{n}{20}$	

SODIUM ACETATE.

2 $\frac{n}{4}$	2 $\frac{n}{2}$	2 $\frac{n}{4}$ *		1 $\frac{n}{1}$		2 $\frac{n}{4}$ †	2 $\frac{n}{2}$

*No. 647. Some injured. †No. 645. Very few grew.

start to resist the further action of the toxic solution. With Uromyces results were somewhat variable, but undeniable proof was obtained that growth is not prevented by $\frac{n}{100}$.

Ammonium hydroxid was tried only with Penicillium, and $\frac{n}{14}$ prevented growth.

Potassium iodid and bromid.—These agree in being non-toxic toward Botrytis, Macrosporium, and Uromyces at $\frac{n}{20}$, and to Penicillium at $\frac{n}{10}$.

Sodium acetate.—This allowed growth of Botrytis, Macrosporium, and Uromyces at $\frac{n}{4}$, and of Penicillium at normal, while $\frac{n}{2}$ prevented Botrytis and Uromyces from growing.

Magnesium sulfate, barium chlorid, ammonium chlorid, magnesium chlorid.— By two tests each, these all proved harmless to Penicillium at $\frac{n}{10}$ strength.

A general tabulation of these results is presented in table XVII which will be readily comprehended. The strength expressed represents the dilution of normal solution required to prevent most of the spores from germinating. If any growth occurred, there would be only a few isolated cases of germination. In table XVIII the strength is indicated in parts per million.

The signs $>$ and $<$ are the common mathematical signs for "greater than" and "less than." For example, the killing strength of KCN for Glœosporium is greater than $\frac{n}{400}$, while that of potassium bichromate for Botrytis is less than $\frac{n}{640}$. The molecular weight of the salt as used in making up the solutions is given, with formula of each substance.

From the more interesting and important generalizations of this table a few may be indicated.

Mercuric chlorid is by far the most poisonous substance used, while potassium cyanid has low toxic power. This may be partially explained by the evaporation of the potassium cyanid from the drop, but this explanation surely cannot apply in the

TABLE XVII

STRENGTH REQUIRED TO PREVENT GERMINATION

[Expressed as parts of normal solution]

Substance	Botrytis	Macrosporium	Glœosporium	Penicillium	Uromyces
$HgCl_2$ 239.2	$\frac{n}{51200}$	$\frac{n}{102400}$		$> \frac{n}{3200}$	$\frac{n}{6400}$
KCN 64.7		$\frac{n}{50}$	$> \frac{n}{400}$	$\frac{n}{100}$	$\frac{n}{100}$
HCl 36.19		$> \frac{n}{50}$	$> \frac{n}{100}$	$> \frac{n}{50}$	$\frac{n}{50}$
H_2SO_4 97.34		$> \frac{n}{50}$	$> \frac{n}{100}$	$> \frac{n}{50}$	$\frac{n}{100}$
C_2H_6O 45.7	$> n$	$> 5n$		n	$> 5n$
$CuSO_4+5H_2O$ 247.54	$\frac{n}{3200}$	$\frac{n}{6400}$		$\frac{n}{200}$	$\frac{n}{3200}$
$Cu(NO_3)_2+3H_2O$ 239.6	$\frac{n}{3200}$	$> \frac{n}{3200}$		$\frac{n}{200}$	$\frac{n}{3200}$
$Cu(C_2H_3O_2)_2$ 179.96	$\frac{n}{3200}$	$\frac{n}{3200}$		$\frac{n}{800}$	$\frac{n}{800}$
$CuCl_2+2H_2O$ 166.96		$\frac{n}{3200}$ or less	$\frac{n}{6400}$	$\frac{n}{200}$	$\frac{n}{3200}$
K_2CrO_4 192.92	$< \frac{n}{640}$	$\frac{n}{40}$		$< \frac{n}{640}$	$\frac{n}{40}$
$K_2Cr_2O_7$ 292.2	$< \frac{n}{1280}$	$\frac{n}{1280}$		$< \frac{n}{1600}$	$\frac{n}{640}$
NaCl 58.18	$> \frac{n}{2}$	$> n$		$> 2n$	$\frac{n}{2}$
KOH 54.74		$> \frac{n}{100}$		$\frac{n}{40}$	$> \frac{n}{100}$
NaOH 38.76		$> \frac{n}{100}$		$\frac{n}{40}$	$> \frac{n}{100}$
NH_4NO_3 79.52	$\frac{n}{2}$			$\frac{n}{2}$	$\frac{n}{2}$
KI 164.76	$> \frac{n}{20}$	$> \frac{n}{20}$		$> \frac{n}{10}$	$> \frac{n}{20}$
KBr 118.21	$> \frac{n}{20}$	$> \frac{n}{20}$		$> \frac{n}{10}$	$\frac{n}{20}$
$Na(C_2H_3O_2)+3H_2O$ 134.71	$\frac{n}{2}$	$> \frac{n}{4}$		$> n$	$\frac{n}{2}$
$MgSO_4+7H_2O$ 245 7				$> \frac{n}{10}$	
$BaCl_2+2H_2O$ 242.13				$> \frac{n}{10}$	
NH_4Cl 53.13				$> \frac{n}{10}$	
$MgCl_2+6H_2O$ 201.88				$> \frac{n}{10}$	
$K_2Mn_2O_8$ 313.94				$> \frac{n}{10}$	$\frac{n}{200}$
NH_4OH 34.82				$> \frac{n}{25}$	

case of Penicillium, which uniformly grew in $\frac{n}{200}$. So the fact must be accepted that KCN has a low toxic power for these fungi.

TABLE XVIII

STRENGTH REQUIRED TO PREVENT GERMINATION

[Expressed as parts per million]

Substance	Botrytis	Macrosporium	Gloeosporium	Penicillium	Uromyces
$HgCl_2$ 239.2	4.6	2.3		74	37
KCN 64.7.....		1294	> 162	647	647
HCl 36.19.....		> 724	> 362	> 724	724
H_2SO_4 97.34.....		> 1947	> 973	> 1947	973
C_2H_6O 45.7	> 45700	> 228500		45700	> 228500
$CuSO_4+5H_2O$ 247.54	49—77	25—38		791—1237	49—77
$Cu(NO_3)_2+3H_2O$ 239.6	58	> 58		930	58
$Cu(C_2H_3O_2)_2$ 179.96	56	56		225	225
$CuCl_2+2H_2O$ 166.96		20 or less	20	656	41
K_2CrO_4 192.92	< 301	4823		< 301	4823
$K_2Cr_2O_7$ 292.2.....	< 228	228		< 183	456
NaCl 58.18..... .	> 29090	> 59190		< 119380	29090
KOH 54.74		> 547		1368	> 547
NaOH 38.76		> 388		1938	> 388
NH_4NO_3 79.52.....	39760			39760	39760
KI 164.76.....	> 8238	> 8238		> 16476	> 8238
KBr 118.21	> 5910	> 5910		> 11820	> 5910
$Na(C_2H_3O_2)+3H_2O$ 134.71	45500	> 20250		> 81000	40500
$MgSO_4+7H_2O$ 245.7				> 12554	
$BaCl_2+2H_2O$ 242.13				> 20637	
NH_4Cl 53.13.....				> 5313	
$MgCl_2+6H_2O$ 201.88				> 9460	
$K_2Mn_2O_8$ 313.94...	392			> 31394	1570
NH_4OH 34.82.....					

H_2SO_4 and HCl agree closely in toxic effect upon these fungi and are of also about the same toxic action as KCN. The fatal strength for H_2SO_4 is nearly a one per cent. solution.

All of the copper salts agree closely in toxic action.

Between potassium chromate and bichromate there is a remarkable variance; the bichromate has twice the effect upon Botrytis, thirty-two times the effect upon Macrosporium and sixteen times upon Uromyces that the chromate does.

In all the cases considered so far, it will be noticed that with the exception of Penicillium, Uromyces will withstand as great or greater strength than any of the other fungi tried. With NaCl we have a case, however, in which the Macrosporium survives even a greater strength than the Uromyces. The same anomaly is observed with HCl and H_2SO_4 upon these fungi. So it seems that although a fungus may, generally speaking, be more resistant to the action of salts or acids than other fungi are, there may be some particular substances which will affect this fungus at less strength than is required for the other and usually weaker fungus. This fact is especially important in the application of fungicides, in that a fungicide which is most effective for one fungus is not necessarily so for all fungi. It may also be noticed that although Uromyces is generally more resistant than Botrytis and Macrosporium, Uromyces is the most susceptible to the action of NaCl.

The hydroxids KOH, NaOH, and NH_4OH gave quite uniform results, and show a low toxic power. In the case of the hanging drop this might partially be explained by the neutralization by CO_2; but, substantiated as it is by parallel experiments in gross culture with a Penicillium, the fact must be accepted that the hydroxids are of low toxic action on these fungi.

Potassium permanganate is of very low toxic power, but is of peculiar interest in that it has the power of coloring the uredospores a dense black, while the teleutospores were but slightly if at all darkened. The other records made in table XVII show that the solution is practically non-toxic.

An inspection of this table will show that, of the five fungi tried, Penicillium is usually more resistant than any of the others. This is rather to be explained by the means of culture than by any structural or selective difference in the fungi themselves.

Single spores might easily have been protected from the action of the fungicide by the nutrient medium. This idea is further supported by the fact, frequently noted in drop cultures of Uromyces, that often a spore in the midst of a close bunch would grow when others near it and unprotected would fail. This was of such frequent occurrence as practically to prove that

TABLE XIX.

SHOWING LIMIT PREVENTING SPORADIC GERMINATION.

Substance	Botrytis	Gloeosporium	Macrosporium	Penicillium	Uromyces
$HgCl_2$	$\frac{n}{25600}$		$\frac{n}{51200}$	$> \frac{n}{3200}$	$\frac{n}{6400}$
KCN		$> \frac{n}{400}$	$> \frac{n}{50}$	$\frac{n}{100}$	$> \frac{n}{100}$
HCl		$> \frac{n}{100}$	$> \frac{n}{50}$	$> \frac{n}{50}$	$> \frac{n}{50}$
H_2SO_3		$> \frac{n}{100}$	$> \frac{n}{50}$	$> \frac{n}{50}$	$> \frac{n}{100}$
C_2H_6O	$> n$		$> 5n$	$\frac{n}{2}$	$> \frac{n}{5}$
$CuSO_4$	$\frac{n}{3200}$		$\frac{n}{3200}$	$\frac{n}{200}$	$> \frac{n}{100}$
$Cu(NO_3)_2$	$\frac{n}{3200}$			$\frac{n}{200}$	$\frac{n}{3200}$
$Cu(C_2H_3O_2)_2$	$\frac{n}{3200}$		$\frac{n}{1600}$	$\frac{n}{800}$	$\frac{n}{200}$
$CuCl_2$		$\frac{n}{6400}$	$\frac{n}{6400}$	$\frac{n}{200}$	$> \frac{n}{1600}$
$K_2Mn_2O_8$		$\frac{n}{800}$		$\frac{n}{400}$	$> \frac{n}{100}$
K_2CrO_4	$< \frac{n}{640}$		$\frac{n}{40}$	$< \frac{n}{640}$	$\frac{n}{10}$
$K_2Cr_2O_7$	$< \frac{n}{1280}$		$\frac{n}{1280}$	$< \frac{n}{1600}$	$\frac{n}{320}$
NaCl	$> \frac{n}{2}$		$> n$	$> \frac{2n}{1}$	n
KOH			$> \frac{n}{100}$	$> \frac{n}{20}$	$> \frac{n}{100}$
NaOH			$> \frac{n}{100}$	$\frac{n}{20}$	$> \frac{n}{100}$
NH_4OH				$> \frac{n}{28}$	

close contact of the spores could prevent the toxic effect of the chemical.

Generally speaking, Botrytis required a stronger solution to kill than did the Macrosporium, while Uromyces required much greater strength than either of them. This might have been expected from the relative thickness of their walls, and is further illustrated by table XIX, which gives the strength of solution required to prevent completely the growth of spores. Exceptions to this generalization occur, however, as has already been pointed out, which indicate a selective difference. Some fungi on experimentation gave with some chemicals a sharp and definite killing point. Others were gradually weakened or the number of germinating spores decreased as the strength of the solution increased. This second phase is particularly well illustrated in the cultures of Uromyces. With each chemical a strength could be found which just perceptibly injured the fungus, and another which prevented most spores from germinating. This is what has previously been given as the killing strength. At this strength one of two things occurred: either about the usual number grew, but grew only slightly and in stunted or often distorted manner; or, in each culture, nearly all the spores failed utterly to grow, while one or a half dozen in the hundreds of a culture would grow and grow usually vigorously and apparently uninjured. In order to kill these few persistent spores much greater strength was required. Thus, in potassium chromate, for Uromyces, $\frac{n}{40}$ killed or prevented most growth. But some spores grew even in $\frac{n}{20}$, and $\frac{n}{10}$ was necessary to inhibit growth completely. On the other hand $\frac{n}{80}$ did weaken growth somewhat. So there is established a wide range between the weakest solution injuring the fungus and the weakest solution surely preventing growth.

Table XX shows the variation in range of susceptibility. In this table two concentrations are named for each fungus. At the weaker normal growth took place, while the stronger completely inhibited growth.

It is here to be noticed that Uromyces gives a remarkable

TABLE XX.

SHOWING RANGE OF SUSCEPTIBILITY.

Substance	Botrytis	Gloeosporium	Macrosporium	Penicillium	Uromyces
$HgCl_2$	$\frac{n}{102400}$ $\frac{n}{25600}$		$\frac{n}{819200}$ $\frac{n}{51200}$		$\frac{n}{25600}$ $\frac{n}{6400}$
KCN			$\frac{n}{100}$ $> \frac{n}{50}$	$\frac{n}{200}$ $\frac{n}{100}$	$< \frac{n}{200}$ $> \frac{n}{100}$
HCl			$\frac{n}{100}$ $> \frac{n}{50}$		$\frac{n}{800}$ $> \frac{n}{50}$
H_2SO_4		$\frac{n}{200}$ $> \frac{n}{100}$			
C_2H_6O				$\frac{n}{1}$ $\frac{n}{2}$	
$CuSO_4$	$\frac{n}{12800}$ $\frac{n}{3200}$		$\frac{n}{12800}$ $\frac{n}{3200}$	$\frac{n}{400}$ $\frac{n}{200}$	$\frac{n}{12800}$ $> \frac{n}{100}$
$Cu(NO_3)_2$	$\frac{n}{6400}$ $\frac{n}{3200}$			$\frac{n}{400}$ $\frac{n}{200}$	$\frac{n}{6400}$ $\frac{n}{3200}$
$Cu(C_2H_3O_2)_2$	$\frac{n}{3200}$ $\frac{n}{6400}$		$\frac{n}{6400}$ $\frac{n}{1600}$	$\frac{n}{1600}$ $\frac{n}{800}$	$\frac{n}{6400}$ $\frac{n}{200}$
$CuCl_2$		$\frac{n}{12800}$ $\frac{n}{6400}$		$\frac{n}{400}$ $\frac{n}{200}$	$\frac{n}{6400}$ $> \frac{n}{1600}$
$K_2Mn_2O_8$		$\frac{n}{1600}$ $\frac{n}{800}$		$\frac{n}{400}$	$\frac{n}{400}$ $> \frac{n}{100}$
K_2CrO_4					$\frac{n}{160}$ $\frac{n}{10}$
K_2CrO_7			$< \frac{n}{3200}$ $\frac{n}{1280}$		$< \frac{n}{3200}$ $\frac{n}{320}$
KOH				$\frac{n}{50}$ $> \frac{n}{20}$	
NaOH				$\frac{n}{50}$ $\frac{n}{20}$	

range, particularly with copper sulfate, in which most spores were killed at $\frac{n}{3200}$. Some injury was done by $\frac{n}{12800}$, but some spores grew in even so strong a solution as $\frac{n}{100}$.

A general survey of the tables will show that the following list of chemicals may be selected as having practically no toxic action unless in great strength, as they were tried at $\frac{n}{10}$ with no toxic action, and this was in every case greater than a ½ per cent. solution: $K_2Mn_2O_8$, $MgCl_2$, NH_4Cl, $BaCl_2$, $MgSO_4$, $Na(C_2H_3O_2)$, KBr, KI, NH_4NO_3, NaCl, C_2H_6O.

HYDROLYTIC DISSOCIATION.

Salts in aqueous solution present certain deviations regarding the changes of freezing and boiling point (and also other optical physical, and chemical deviations) which are not in accord with the general laws for solutions containing the number of molecules theoretically supposed to be present. "Thus a solution of KCl + 100 H_2O, instead of showing a lowering of vapor pressure of .01 as required by the law, shows a lowering of about double this. Solutions in alcohol behave like other substances and give normal diminution of vapor pressure."[4] In general the behavior of such aqueous solutions of salts, bases, or acids is such as might be expected if they contained more molecules than their formula indicates.

These phenomena led Arrhenius[5] to the conclusion that each molecule or some of the molecules are separated into part molecules or ions, a term long used by the physicist.

According to this theory of hydrolytic dissociation a solution of mercuric chlorid does not consist of water and molecules of mercuric chlorid, but does consist of water containing ions of mercury and ions of chlorin, designated as Hg^+ and Cl^-, according as the element is electro-positive or electro-negative in electrolytic dissociation.

Careful distinction should be drawn between an element in the condition of dissociation and in a molecular condition. Thus

[4] OSTWALD: Solutions, trans. by Muir, p. 187.

[5] Zeits. f. phys. Chem. 1: 631. 1887.

ions of sodium are very different in their chemical, physical, and physiological properties from molecules of sodium.

Arrhenius, as quoted by Ostwald (*l. c.*), was thus led to the conclusion that "the properties of salt solutions must be capable of representation as the binary sums of the properties of the ions." This generalization has later been made more particular and has been qualified slightly by Kahlenberg and True (*l. c.*), who extend their reasoning to the domain of physiological effects. They say: "Now, if, in the case of the solutions in question, all the chemical and physical properties are due to the properties of the ions plus those of the undissociated molecules it contains, it seems very probable that the physiological effects produced by such solutions are due to these."

The above proposition is then amply substantiated by these authors and by F. D. Heald (*l. c.*) in a series of experiments upon seedlings of flowering plants.

TABLE XXI.

Non-poisonous			Poisonous		
Substance	Cathion	Anion	Substance	Cathion	Anion
$MgSO^4$	Mg +	SO_4 —	$HgCl_2$	Hg +	
$BaCl_2$	Ba +	Cl —	HCl	H +	
NaCl	Na +	Cl —	H_2SO_4	H +	
MgCl	Mg +	Cl —	KCN		CN —
$NaC_2H_3O_2$	Na +	$C_2H_3O_2$ —	$CuSO_4$	Cu +	
KBr	K +	Br —	$Cu(NO_3)_2$	Cu +	
KI	K +	I —	$Cu(C_2H_3O_2)_2$	Cu +	
$K_2Mn_2O_8$	K +	MnO_4	$CuCl_2$	Cu +	
NH_4NO_3			K_2CrO_4		CrO_4 —
NH_4Cl			$K_2Cr_2O_7$		Cr_2O_7 —
C_2H_6O			KOH		OH —
			NaOH		OH —
			NH_4OH		OH —

In the first column of table XXI is given a list of salts which have been proven non-poisonous. The strengths were such that there were in the solution many undissociated molecules; many also of the molecules were dissociated; hence, as these solutions proved non-toxic at the strength used, it may be

concluded that both the molecules and the ions, both negative and positive, are devoid of toxic action.

The two next columns of this table show the ions into which the salts are separated. Here then is proof that to the fungi under investigation the cathions Mg, Ba, Na, and K are non-toxic. The anions SO_4, Cl, Br, I, MnO_4, and $C_2H_3O_2$ are non-toxic at the strength used. The second half of table XXI shows those salts which were found to have toxic action.

As Cl^- ions have previously been proven non-toxic the effect must rest with the molecule of $HgCl_2$ or with the ion of Hg^+. The salt at the strength used was almost completely dissociated, hence the effect is due to the Hg^+ ion, which was the most powerful one experimented with.

With the two acids, HCl and H_2SO_4, the anions had proven non-toxic; so, by similar reasoning, the poisonous property rests with the H^+ ion. As H_2SO_4 contains twice as much H^+ as does HCl it should have twice its toxic power in equi-molecular solutions. This statement has met no adverse results in experiment, but there has been slight, though by no means positive evidence, to sustain it.

With KCN the cathion is non-toxic. The CN^- then must be poisonous, and it has about the same toxic action as does H^+.

With all the copper salts the anions are non-toxic, hence the poison is in the molecule or in the copper, and in the more dilute solutions it undeniably rests with the copper. As each copper compound has as many atoms of copper per molecule as the others it would be equally toxic. This expectation is almost fully met, with the exception of copper acetate for Penicillium and Uromyces, and of copper sulfate for Macrosporium. These three slight deviations from the theory stand against thirteen observations with the copper salts tending to support it.

In the potassium chromate and bichromate solutions the poisonous action rests evidently with the anions. The bichromate is in every case more poisonous and in most cases far more poisonous than the chromate, as may be seen by tables XII and XIII.

With the hydroxids the toxic effect rests with the anion, and as far as positive results were secured, they agree precisely. It may be noted, in passing, that the Bordeaux mixture, 22-gallon formula, estimated on basis of copper content, would be of about $\frac{n}{4}$ strength, whereas these experiments show $\frac{n}{200}$ for copper is sufficient to prevent growth, except in extremely rare cases, while $\frac{n}{3200}$ is usually fatal to the spores with which it comes in contact. It is possible, however, that in Bordeaux mixture the copper may enter into the formation of a complex molecule, producing in dissociation a complex ion containing copper which is inferior to the copper ion itself in toxic action. This subject, however, is now under investigation and will be treated of in a separate paper.

TABLE XXII.

	Pisum	Zea	Lupinus	Penicillium	Uromyces
HCl	$\frac{n}{12800}$	$\frac{n}{3200}$	$\frac{n}{6400}$	$> \frac{n}{50}$	$\frac{n}{50}$
H_2SO_4	$\frac{n}{12800}$	$\frac{n}{3200}$	$\frac{n}{6400}$	$> \frac{n}{50}$	$\frac{n}{100}$
$CuCl_2$	$\frac{n}{51200}$	$\frac{n}{102400}$	$\frac{n}{25600}$	$\frac{n}{100}$	$\frac{n}{3200}$
$CuSO_4$	$\frac{n}{51200}$	$\frac{n}{102400}$	$\frac{n}{25600}$	$\frac{n}{200}$	$\frac{n}{3200}$
$Cu(C_2H_3O_2)_2$	$\frac{n}{51200}$	$\frac{n}{102400}$	$\frac{n}{25600}$	$\frac{n}{800}$	$\frac{n}{800}$
$HgCl_2$	$\frac{n}{204800}$	$\frac{n}{51200}$	$\frac{n}{12800}$	$> \frac{n}{3200}$	$\frac{n}{6400}$
KCN	$\frac{n}{12800}$	$\frac{n}{6400}$	$\frac{n}{6400}$	$\frac{n}{100}$	$\frac{n}{100}$

It may be of interest to compare the results of this work on fungi with that of Kahlenberg and True on phanerogams. Table XXII brings together the results upon such substances as we have used in common, and also renders it possible to see at a glance the relative susceptibility of the fungi and phanerogams.

The first two columns are the result of work by Heald, the third that of Kahlenberg and True, and the last two are recorded

for the first time in this paper. An apparent but not real discrepancy arises from the fact that, in considering the two acids, the other authors have estimated the normal solution upon the basis of hydrogen present, whereas in mine, it is on the basis of the whole molecule. In view of this it will be seen that our results agree in making H ions as toxic in one acid as in the other and that about equal to the action of CN ions. It should be also noticed that their results represent strengths in which the plants would just grow, and mine a strength in which they would just not grow.

In general the fungi are far more resistant to action of these salts than are the higher plants. The authors quoted find copper approximately thirty-two times as toxic as hydrogen. My results show it sixty-four times as toxic for the fungi. The results with Pisum show Hg to be four times as toxic as copper ions, while with Zea and Lupinus the copper is twice as toxic as the Hg ion. The fungi show Hg twice as toxic as Cu. They show Cu to be about four times as toxic on Lupinus and Zea as are H or Cu ions. It would be interesting to know whether the HCN dissociated would be one half as strong as Cu, as would seem probable from theory.

TABLE XXIII.

SHOWING RATIO OF TOXIC ACTION.

	Pisum	Zea	Lupinus	Uromyces
H:CN	1:1	1:2	1:1	1:2
H:Cu	1:4	1:32	1:4	1:64
H:Hg	1:16	1:16	1:2	1:128

These results, and others along this line, are collated in table XXIII, in which hydrogen, both on account of its low atomic weight and its low toxic effect, is taken as a standard and the toxic action of other ions with various plants are represented as ratios.

It has been suggested that the toxic action may be some

function of the atomic weight of the element. To say the least, such a supposition is not strongly supported by this table.

It may be well to add that where the words killed, dead, fatal, etc., have been used it is not intended to imply that life was really extinct, but merely that it was not evident. Experiments are now under way to determine, if possible, whether spores which have been prevented from growth by a toxic solution can grow on being placed in one not toxic.

SUMMARY.

1. Mercuric chlorid is the strongest chemical used in its toxic effect upon the fungi.

2. Potassium cyanid is remarkably weak considering its great toxic action on animals.

3. Various fungi offer different resistance to poisons.

4. The limits of resistance vary in the same species.

5. Alcohol and sodium chloride have a stimulating effect.

6. In general the results are in accord with the theory of hydrolytic dissociation.

7. A chemical may be twice as powerful as another against one fungus, but acting upon another fungus an entirely different ratio may be sustained.

8. The spores of fungi are less susceptible than the roots of seedlings.

9. The Bordeaux mixture holds far more copper than would be needed if it dissociated into simple copper ions.

10. The cathions Hg, H, and Cu are poisonous.

11. The anions CN, CrO_4, Cr_2O_7 and OH are poisonous.

12. The halogen anions are not poisonous.

13. Uromyces offers the greatest range in its susceptibility to poisons.

14. The secondary spores of anthracnoses increase in abundance under the adverse conditions of a toxic solution.

15. Spores protected by actual contact with others may germinate and the tube may grow through a solution which in itself

would have prevented the germination of the spore had it been in contact with it.

16. Peculiar knotted or twisted hyphæ frequently result from the attempt to grow in a poisonous solution.

17. A spore may be able to germinate and grow slightly in a solution but still be unable to attain full development.

18. Potassium permanganate at certain strengths acts as a selective stain, differentiating uredo- from teleutospores of *Uromyces caryophyllinus*.

19. Bread may be moistened with a solution which prevents germination of spores. This solution may evaporate and the spores can then grow.

20. An occasional spore may germinate and grow *perfectly normally* in a solution which prevents hundreds of normal spores around it from germinating.

21. Penicillium in a nutrient medium offers greater resistance to poisons than do any of the other fungi worked upon.

22. Uromyces does not diminish in vigor of growth with the increased strength of the poison, but it does diminish in the percentage of spores which germinate.

In conclusion I offer my most grateful thanks to Dr. B. D. Halsted for much kind assistance and advice as well as for preliminary training in former years; to Dr. W. A. Kellerman for his courtesy in extending to me the privileges of his physiological laboratory and also for material and advice; to Mr. E. M. Wilcox for many courtesies in the laboratory.

THE UNIVERSITY OF CHICAGO.

THE PHYSIOLOGICAL ACTION OF CERTAIN PLASMOLYZING AGENTS.

RODNEY H. TRUE.

INTRODUCTORY.

IN the course of an investigation in which the writer was concerned regarding the physiological action of certain sodium salts, various degrees of destructiveness were observed. In some of the weakest salts, it seemed possible that the osmotic action as well as the chemically harmful properties of the substances might play a rôle, so concentrated were the solutions in which the test plants first survived. It seemed to be very desirable to analyze, if possible, the injurious physiological action of some of the commoner and less harmful salts into its osmotic (physical) and toxic (chemical) components, should it appear that both contribute to the results seen.

The desirability of some clearer understanding of the action of these substances seemed the greater by reason of the frequent use as plasmolyzing agents to which certain of them have long been put by plant physiologists. Sodium chlorid and potassium nitrate, especially, have been much employed in this way. In thus using them, botanists have followed the lead of De Vries, (1) who first applied these substances in this way, and have assumed them to be essentially harmless, as asserted by De Vries (p. 12). He says, "Es ist eine sehr verbreitete irrthümliche Ansicht, dass concentrirte Salzlösungen (z. B., eine Kochsalzlösung von 10–20 %) für des Leben der Pflanzenzelle gefährlich seien." Davenport (2) more recently says, "It is not easy to find a reagent of which we may be certain that it acts only osmotically. NaCl is probably more generally useful in this way than any other substance."

As far as the writer knows, no attempt has been made hitherto to analyze thus the action of a substance, beyond the single

one made by Plateau (3), who used as test objects animals, mainly invertebrates. His experiments turned out unfortunately on account of the fundamental error made in using as comparative solutions percentage concentrations. Recently, Davenport (2) has outlined a method of analysis, in itself correct, but likely to lead to error in many cases through the choice of sodium chlorid as a standard substance assumed to exert a purely osmotic effect.

METHOD.

In attempting to analyze the injurious action of a compound into its osmotic and its toxic constituents, a standard solution which has a known osmotic action, and is not open to the suspicion of being in any degree toxic, may be selected for purposes of comparison.

As such a standard substance, I have selected cane sugar. It occurs normally in plant cells, often in high concentration, twenty per cent. having been observed in the sugar beet (4). As has been often proved, it is a most excellent plant food when supplied in cultures. In searching through the results of investigators who have made use of this substance in cultures, I have failed to find in any case toxic action attributed to cane sugar. In higher concentrations it proves harmful on exposure of plants to its action for long periods of time, an effect that seems to be amply accounted for by the osmotic properties of such solutions. Moreover, it diffuses rather slowly, and is less liable to injure the organism by the sudden withdrawal of water than is the case with substances of more rapid osmotic action. A limited opportunity for the cell to accommodate itself to the changing concentration is gained in the more slowly diffusing substances.

Having chosen cane sugar as a standard of pure osmotic effect, solutions were made up on the basis of a molecular weight of substance in the requisite numbers of liters required to give the concentrations desired. Tufts of Spirogyra filaments, first rinsed thoroughly in duplicate solutions to prevent dilution of those used in the experiments, were placed in the desired concentra-

tions and left for twenty-four hours. At the end of this time, the condition of the algæ was examined into with greatest care, and the strongest concentration in which they survived was noted. This limit I have termed the boundary concentration, and regard it as a measure of the purely osmotic action capable of being sustained by Spirogyra. Having determined this point, I calculated, by the use of methods in no way involving the living cell, the concentrations of the solutions of other substances to be studied, which have an osmotic value equal to that of the experimental boundary concentration of cane sugar. The next step was to determine experimentally as just described, the boundary concentration of each substance under study.

If the algæ survived in a concentration greater than that calculated from the value of cane sugar, the conclusion would necessarily follow that the substance in question was less harmful to the plants than sugar. This condition of things was in no case realized. If the algæ first survived in the calculated concentration, the action of the substance would be purely osmotic and equal to that of cane sugar. If the algæ should first survive in a concentration more dilute than the calculated boundary concentration, the substance in question would be more harmful than sugar.

In the realization of the third case, injury by one or both of two possible methods might be wrought; first, by a very rapid extraction of water from the cell, violence might be done to the protoplast through the lack of opportunity for the organism to accommodate itself to the change; second, toxic action due to the chemical interference of the substance in solution with the molecules of living substance might also take place. In each special case, it would be necessary to ascertain the kind of injury operating. In doing this certain plain considerations should be borne in mind. Should Spirogyra be found to survive at a concentration greater than that causing plasmolysis and less than the calculated boundary, the deleterious action would in great probability be due to the osmotic properties of the solution, a point again to be touched on in this paper. If, however, the

algæ should die in a concentration less in osmotic value than the cell sap, *i. e.*, at a concentration weaker than the plasmolyzing strength, death could hardly be attributed to the water-extracting properties of the molecules or ions.

EXPERIMENTAL RESULTS.

I have studied, according to the method just described, those substances which have been most used by biologists as plasmolyzing agents, cane sugar, glycerin, sodium chlorid, and potassium nitrate.

The numerical data obtained are brought together for more ready reference in the following table. Three important points determined for each substance are presented: (1) the concentration of the solution in which plasmolysis begins in the Spirogyra studied stated in gram-molecules of the substance per liter of water; (2) the calculated boundary concentration, assuming a purely osmotic action of a type not more injurious than that seen in cane sugar; (3) the boundary concentration found by experiment.

The temperature varied between 22° and 30° C. as limits. Although the significance of relationships is lost when the concentrations are so stated, I have added percentage values to facilitate comparison with results obtained by other investigators. As an "antidote" for the percentage values, the molecular weights of the substances under study are also added.

Substance	Mol. wt.	Plasmolyzing concentration		Calculated boundary concentration		Experimental boundary concentration	
		gm. mol. per l.	Per cent.	gm. mol. per l.	Per cent.	gm. mol. per l.	Per cent.
Cane sugar.....	342.0	0.33 ($\frac{1}{3}$)	11.4			0.75 ($\frac{3}{4}$)	25.7
Glycerin	92.0	0.33 ($\frac{1}{3}$)	3.1	0.75 ($\frac{3}{4}$)	6.9	0.50 ($\frac{1}{2}$)	4.60
Sodium chlorid..	58.5	0.25 ($\frac{1}{4}$)	1.5	0.46	2.7	0.10 ($\frac{1}{10}$)	0.58
Potassium nitrate	101.0	0.25 ($\frac{1}{4}$)	2.5	0.47	4.5	0.06 ($\frac{1}{16}$)	0.63

As appears in this table, Spirogyra just begins to plasmolyze in a cane sugar solution having a concentration of $\frac{1}{3}$ gm. mol

per liter, and the most concentrated solution in which it can survive is ¾ gm. mol. Since cane sugar is assumed to have a purely osmotic action, we have in ¾ gm. mol. of cane sugar per liter of water an osmotic quantity just small enough to permit life, and any other substance acting likewise in a purely osmotic manner will have as its boundary concentration, that concentration which is equal in its osmotic action to a solution of cane sugar containing ¾ gm. mol. per liter.

We are able, assuming purely osmotic action, to calculate the concentration in which the algæ will just survive. The boundary concentration of cane sugar, the osmotic value of cane sugar and that of the substance in question, being given, the boundary concentration would be found to be related to that for cane sugar inversely as the known osmotic values, according to the proportion

$$S : x :: ox : oS$$

in which S is the boundary solution of cane sugar; x the boundary solution of the substance; ox the osmotic value of the substance; and oS the osmotic value of cane sugar.

Osmotic pressure is known to depend directly on the number of molecules or part molecules, ions, in the solution, and whatever be the size of the molecules, an equal number will produce an equal osmotic pressure. Since the glycerin molecule undergoes no splitting into ions, like fractions of a gram molecule of cane sugar and of glycerin per liter of water should have the same osmotic value. Hence, assuming physiological properties like those of cane sugar the theoretical boundary concentrations should be the same, ¾ gm. mol. per liter. It is seen, however, that Spirogyra is not able to survive under the conditions of the experiment, until a solution containing but one-half gm. mol. per liter is reached. It should be noted, however, that this concentration is stronger than that first causing plasmolysis.

Why is glycerin more harmful than cane sugar? In spite of repeated experiments, no change of position could be determined for the boundary concentration. Since the Spirogyra still survives in a concentration stronger osmotically than the cell sap,

a toxic action seems hardly probable. It has been long known to physiologists that glycerin (**5**) penetrates the cell wall and the protoplast very quickly (**6**) and can be demonstrated in the cell sap. Thus plasmolysis is rapidly diminished. This speaks for the rapid penetration of the cell by glycerin and the question suggests itself whether the consequent loss of time to accommodate itself to the decided osmotic changes brought about by the solution may not account in some measure for the greater harmfulness seen in glycerin. This question, however, will receive further attention.

In the case of sodium chlorid, one finds a different condition of things. As appears in the table of results, common salt, NaCl, plasmolyzes Spirogyra cells first at a concentration of $\frac{1}{4}$ gm. mol., and first can be survived when containing $\frac{1}{10}$ gm. mol. only. If we assume for sodium chlorid a purely osmotic action, we are able, by making use of the action of cane sugar as a standard of osmotic effect, to calculate the corresponding concentration of sodium chlorid that should just permit the survival of the alga.

Since the molecules split up in large proportion into ions, each of which exerts an osmotic effect equal to that of a molecule not so split, it is necessary to have recourse to the experimental results of physical chemistry. On the basis of the molecular conductivity of salt solutions, it is possible to calculate the percentage of salt molecules dissociated in a solution of a given strength. The electrical conductivity at the given volume (μ_v) divided by the electrical conductivity at an infinite dilution (μ_∞) gives the degree of dissociation. Since the electrical conductivities are not worked out for all boundary concentrations reached in this study, it has been found necessary to use the closest possible approximation. The error thus occasioned, however, is believed to be not sufficiently large to detract materially from the usefulness of the results, since it is impossible to eliminate many minor inaccuracies when working on a question of this nature.

By using tables of molecular conductivities of NaCl, brought

together perhaps in the most complete and convenient form in the work of Landolt and Börnstein (**7**), one can readily estimate the number of undissociated molecules and of ions in the solution. This number will express the osmotic value of salt when that of cane sugar is taken as one. Knowing, therefore, the boundary concentration of sugar and the osmotic value of NaCl at the different degrees of dilution, we are able to find a theoretical boundary concentration for NaCl, assuming for it a purely osmotic action.

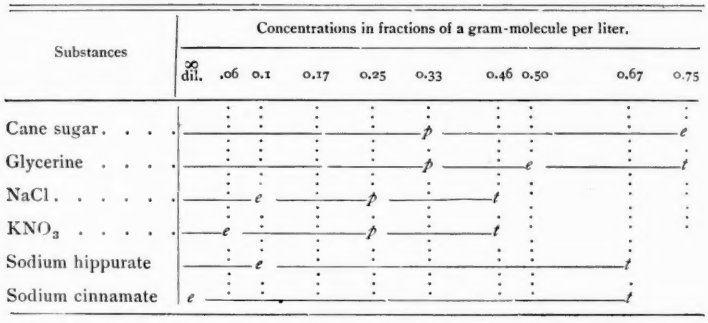
As appears in the table, Spirogyra first survives in NaCl at a concentration of 0.1 gm. mol. per liter instead of 0.46 gm. mol., the approximate boundary required by purely osmotic action. Since the plants succumb in a solution of NaCl hardly one-fourth as concentrated as would be required by pure osmotic action, as seen in sugar, either the method of exerting this osmotic effect is much more disastrous than is seen in the case of sugar, or some form of toxic activity is here exerted by the NaCl. Since the boundary concentration is so dilute (0.1 gm. mol. per l.), it seems extremely improbable that the mere withdrawal of water from the cell sap by the salt solution could exert a harmful effect commensurate with the numerical disparity here observed.

In the case of potassium nitrate (KNO_3), a result very similar to that seen in the case of NaCl was obtained. The salts dissociate in about the same degree under like conditions. A concentration of KNO_3 equal osmotically to the boundary concentration of sugar would be about 0.47 gm. mol. per liter. If the physiological action of KNO_3 were totally osmotic the Spirogyra should first survive in about this concentration. The boundary concentration of KNO_3 determined experimentally was found to be $\frac{1}{16}$ gm. mol. per liter. With an osmotic activity very nearly identical with NaCl, a boundary is found at a greater dilution, indicating a degree of toxic activity somewhat greater than that of NaCl.

In the course of a study by Dr. Kahlenberg and myself of the sodium salts of a number of acids, mainly organic, the boundary concentrations for Spirogyra were obtained. A wide range

of variation was found. In but one instance did a salt give a boundary concentration greater than 0.04 gm. mol. per liter (sodium hippurate, 0.08 gm. mol. per. liter), and in a number of cases the algæ did not survive until a solution containing but 1 gm. mol. in 200 liters was reached, viz., sodium cinnamate and sodium protocatechuate. In no case does it appear probable that osmotic action plays any noticeable rôle in bringing about the death of the plants; in all cases, therefore, practically toxic action only can be invoked as the cause of death. Assuming roughly dissociation in both of these salts to be approximately 15 per cent., the osmotic value of these compounds would be 1.15, that of cane sugar taken as unity. On the assumption of purely osmotic action, the theoretical boundary concentration would lie for each of these salts at about 0.65 gm. mol. per liter. Against these roughly calculated values may be contrasted the experimental boundary concentration, 0.005 gm. mol. per liter. The sodium compound most easily tolerated, sodium hippurate, is seen to act chiefly through its toxic properties, the cinnamate and protocatechuate practically entirely so.

It is interesting in this connection to note that boric acid, the much used antiseptic, shows for Spirogyra less toxicity than any of the above mentioned sodium salts.



In closing this review of the experimental details, a diagram is given which presents in a somewhat more graphic form the

cardinal numerical relations which have served as a basis for the discussion. In this diagram, *p* stands beneath the concentration just beginning to call forth plasmolysis; *t* beneath the concentration representing the theoretical boundary concentration; *e* beneath the concentration experimentally determined to be the boundary concentration.

In view of the results above presented, it appears that plants may be fatally affected both by solutions acting osmotically and by solutions acting through their chemical properties.

In the case of solutions acting osmotically and by this method causing death, it should be pointed out that while osmosis furnishes the means, the operation of which leads to a fatal outcome, chemical processes may very well be here involved. One may imagine that the attraction of the sugar molecules for water results in the removal of water more or less rapidly from the organism enclosed within the cell wall. At first, as the cell sap is relatively dilute, it parts with its water to the larger mass of plasmolytic solution without at a relatively rapid rate. The substances dissolved in the cell sap not being yielded up, the cell sap concentration rises. If this process does not continue beyond a certain point, the organism is able, when osmotic equilibrium is reached, to retain enough water to preserve its organization and to sustain for weeks, or even months, a quiescent existence. If, however, an equilibrium between the cell sap and the surrounding medium is not reached until the water necessary to the maintenance of the integrity of the substance and of the processes of life is encroached upon, death must result and probably in the last analysis through chemical changes. Hence, one may imagine that cane sugar in a solution of too great concentration in time will kill the cell through its interference with the chemical integrity of the substance or processes of the cell exerted along the lines of osmotic activity.

In the case of the other compounds working through their toxic properties, the penetration of the substance into the cell is probably followed more or less promptly by chemical changes due to interference with the compounds essential to life, and

death results without any marked withdrawal of water from the cell substance.

In conclusion, it may now be safely asserted that, whereas there exist very many plants which suffer when removed suddenly from salt water to fresh, and appear to be dependent for life itself on the presence of this substance in the substratum, it seems certain that for Spirogyra, sodium chlorid and potassium nitrate act as poisons. It is my opinion, based on a considerable number of experiments not detailed here, that all sodium and potassium salts injure Spirogyra through their chemical properties chiefly, and exert but a minimal harmful influence through their osmotic properties.

In this discussion, I have assumed the accuracy of the classic conclusion that the plasmolytic method as used by De Vries, Pfeffer, and others gives an essentially correct measure of the concentration of the cell sap.

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THE EARLY BOTANICAL VIEWS OF PRUNUS DOMESTICA LINN.

F. A. WAUGH.

THE European plums have been in cultivation so long that we have lost sight of their wild progenitors. This of itself is likely to introduce confusion into botanical notions of their specific relationships. But this long period of cultivation presents a more prolific source of misunderstanding in the wide diversity of cultural and climatic forms which have naturally arisen. These forms were numerous and diverse when the binomial nomenclature and the *Species Plantarum* began to crystallize our notions of species and botanical varieties. Gerarde says in *The Herball* in 1597 that he had in his garden "more than three score sorts, all fine and rare." In America, especially, we have fallen into a very convenient way of lumping off all the cultivated European plums into *Prunus domestica*, with some slight reservation for *Prunus cerasifera* Ehrh.; but if we go back to the beginning we find that the matter was not always so simple.

Linnæus thought it proper, when he described *Prunus domestica*,[1] to divide it into fourteen botanical varieties. It is altogether probable that differences have increased rather than diminished since then; but, in this country at least, we recognize no botanical varieties at all for this species. What has become of them? It would be interesting to know.

In 1789 Ehrhart[2] separated a single one of these varieties to make his species *Prunus cerasifera*,[3] a species which is generally understood and accepted in this country. Seringe in presenting this group in the second volume of the *Prodromus* (1825) did not accept Ehrhart's species, but retained the varietal

[1] Sp. Pl. 475. 1753. [1st ed.]

[2] Beiträge zur Naturkunde **4**: 17. 1689.

[3] *Prunus cerasifera* Ehrh. = *P. Myrobalana* (Linn.) Lois.

name of Linnæus. At the same time he reduced the fourteen varieties given by Linnæus to eight of his own. So the consolidation has gone on, till now we have nothing left either in our botany or in our horticulture, except the names *Prunus domestica* and *P. cerasifera*, to preserve to us the early view of one of our most important fruits.

It has seemed to me that so important a change is worthy of examination. And besides it will be of some present horticultural interest to know how many distinct types we have included in *Prunus domestica*, and to understand the vicissitudes of their several phylogenies. Just at present the work of hybridizing plums is assuming considerable proportions. Sundry varieties of *Prunus domestica* are being brought into these combinations, and the existence of old and more or less distinct types within the species comes to have a new significance.

As soon, however, as we endeavor to acquaint ourselves with the Linnæan view of these cultivated plums, we meet with serious difficulties. Linnæus had no types at all, in the technical sense. That is, he made his descriptions from literature and not from specimens. He did not even write fresh descriptions from his own garden. Instead of this he took the descriptions bodily from Bauhin's *Pinax*, adding nothing but his own varietal names. The same descriptions, with slight modifications, had meanwhile been used also in Tournefort's *Institutiones*.

The *Prodromus* leaves us in a somewhat better position. For though Seringe took no pains to make clear the connection between his varieties and those of Linnæus, he did, however, refer to certain definite types. The principal ones of these are the figures and descriptions in the two editions of Duhamel's *Traité des Arbres Fruitiers*. These figures and descriptions are fairly accurate and full, and, moreover, the varieties there recorded are nearly all described and figured in many other places, particularly in Poiteau's *Pomologie Française*, and many of them are retained with us to the present day with no more variation than such fruits are subject to under the ordinary methods of bud propagation. With the help of Duhamel we are thus able

GENERAL EXHIBIT OF THE PRE-DE CANDOLLEAN SYNONYMY OF THE VARIETIES OF PRUNUS DOMESTICA LINN.

Bauhin	Tournefort	Linnæus	Seringe
P. rotunda, flava dulcia, Mali amplitudine. P. amygdalina.	P. fructu maximo, rotundo, flavo & dulci. P. fructu Amygdalino.	var. maliformis var. amygdalina ?	var. Armeniaoides.
P. parva ex viridi flavescentia.	P. fructu parvo, ex viridi flavescente.	var. cereola.	var. Claudiana.
P. fructu rotundo, nigropurpureo, dulci. P. magna rubra rotunda.	P. fructu rotundo, nigropurpureo, majori dulci. P. fructu majori, rotundo rubro.	var. myrobalan. var. acinaria.	var. Myrobalana.
P. magna dulcia atrocaerulea. P. parva, dulcia atrocaerulea.	P. fructu magno, dulci, atrocaeruleo. P. fructu parvo, dulci, atrocaeruleo.	var. Damascena.	var. Damascena.
P. magna crassida subacida.	P. fructu magno, crasso, subacido.	var. hungarica.	
P. Augusto maturescentia minora et austeriora. P. parva præcocia.	P. fructu minori, austero. P. fructu parvo, præcoci.	var. augustana ? var. praecox ?	
P. nigra carne dura.	P. fructu nigro, carne dura.	var. pernicona. (var. pertigona.)	var. Turonensis.
P. oblonga caerulea.	P. fructu oblongo caeruleo.	var. juliana.	var. Juliana.
P. coloris cerae ex candido in luteum pallescente. P. ex flavo rufescentia mixti saporis gratissima.	P. fructu cerei coloris. P. Brignoniensis, fructu suavissimo.	var. cerea. var. Brignola ?	var. Catherinea.
			var. Aubertiana.
Pruneoli albi oblongiusculi acidi.	P. fructu albo, oblongiusculo, acido.	var. galatensis ?	var. Pruneauliana.

to read backward through Seringe, Linnæus, Tournefort and Bauhin, and to see more clearly what those early botanists were describing. Of course such a method is always open to mistakes, and it will not do to be too sure that we have Bauhin's exact view of the various groups. The following table will show, as accurately as I am at present able to trace, the relation of the varieties of Bauhin, Tournefort, Linnæus, and Seringe to one another.

It is seen at once that Seringe had very little regard for Linnæus' names in preparing the monograph for the *Prodromus*. Only three of the Linnean variety names are retained. The other groups given in *Species Plantarum* are totally disregarded. This is very unfortunate; for in coming to any understanding of the early botanical types of *Prunus domestica*, Seringe's classification offers much the best basis for study. I have thought it best to accept tentatively the eight varieties as given by Seringe, since they doubtless represent the most distinct, as well as the only well-recorded types, and to study these groups separately. A due respect to the rules of botanical nomenclature, however, makes it necessary to revise some of Seringe's names. It will therefore be better if we give here with this revision a more complete record of the pre-DeCandollean synonymy.

PRE-DECANDOLLEAN SYNONYMY OF THE VARIETIES OF PRUNUS DOMESTICA LINN.

1. Var. MALIFORMIS Linn. (var. *Armenioides* Ser.)
   - P. fructu maximo, rotundo, flavo & dulci Tourn.
   - P. rotunda flava dulcia Mali amplitudina Bauh.
   - P. à Malis cognominata Caes.

   Var. amygdalina Linn?
   - P. fructu Amygdalino Tourn.
   - P. amygdalina Bauh.
   - P. amygdalina Pliny.

2. Var. CEREOLA Linn. (var. *Claudiana* Ser.)
   - P. fructu parvo, ex viridi flavescente Tourn.
   - P. parva ex viridi flavescentia Bauh.
   - P. parva serotina, cereola Gesn.
   - P. viridacia Gesn.
   - P. verdacea Cam.

3. Var. MYROBALAN Linn. (var. *Myrobalana* Ser.)
   P. fructu rotundo, nigro-purpureo, majori dulci Tourn.
   P. fructu rotundo nigro-purpureo dulci Bauh.
   P. cognominata Myrobalanus Clus. (?) Cam. Tab. Ger.
   P. myrobalanus rotundus Eyst.
   Var. acinaria Linn.
   P. fructu majori rotundo, rubro Tourn.
   P. magna robra rotunda Bauh.
   P. asinina Trag. Dod. Lugd. Caes.
4. Var. DAMASCENA Linn. (var. *Damascena* Ser.)
   P. fructu magno, dulci, atro-caeruleo Tourn.
   P. magna dulcia atro-caerulea Bauh.
   P. Damascena Trag. Matth. Dod. et al.
   P. Brunensia Clus.
   P. Ungarica duplicia etc. Matth. Gesn. Lugd.
   P. fructu parvo, dulci, atro-caeruleo Tourn.
   P. parva dulcia atro-caerulea Bauh.
   Var. hungarica Linn.
   P. fructu magno, crasso, subacido Tourn.
   P. magna crassida subacida Bauh.
   P. Ungarica praestantissima Gesn.
   Var. augustana Linn.? (var. angustana Linn. Sp. Pl. 2d. ed.)
   P. fructu minori, austero Tourn.
   P. Augusto maturescentia minora & austeora Bauh.
   P. Augustana & Albanula Caes.
   Var. praecox Linn.?
   P. fructu parvo, praecoci Tourn.
   P. parva praecocia Bauh.
   P. praecociora, a tempore avenacea dicta Gesn.
   P. averaria Taber.
5. Var. PERNICONA Linn. (var. *Turonensis* Ser.)
   (Var. pertigona Linn. Sp. Pl. 2d ed.)
   P. fructu nigro, carne dura Tourn.
   P. nigra carne dura Bauh.
   P. Iberica & Pertigona vocata Trag.
   P. Hispanica Dod.
   P. Perdigona Ludg.
   P. pernicona vulgo Caes.
6. Var. JULIANA Linn. (var. *Juliana* DC.)
   P. fructu oblongo, caeruleo Tourn.
   P. oblonga caerulea Bauh.
   P. dactyla purpurea & ovata Ludg. "qui Noberdiana et Juliana addit."

7. Var. CEREA Linn. (var. *Catherinea* Ser.)
   P. fructu cerei coloris Tourn.
   P. coloris cerae ex candido in luteum palliscente Bauh.
   P. cerea & Ceriola Trag. Dod. Lugd. Taber.
   P. cerea Cord. Gesn.
   P. amygdalina Ger.
   Var. Brignola Linn.?
   P. Brignoniensis, fructu suavissimo Tourn.
   P. ex flavo rufescentia mixti saporis gratissima Bauh.
8. Var. AUBERTIANA, DC.
9. Var. GALATENSIS Linn? (var. *Pruneauliana* Ser.)
   P. fructu albo, oblongiusculo, acido Tourn.
   Pruneoli albi oblongiusculi acidi Bauh.
   P. Galatensia, sive Perani pruneoli Clus.

As has been already said, one of the chief means of tracing these groups is through the cultivated varieties. Perhaps also the greatest good to be gained from an understanding of the botanical types is in the light it throws on the history and relationships of the horticultural forms. Let us examine them in order.

PRUNUS DOMESTICA MALIFORMIS.—For his types of this group (var. *Armenioides* Ser.), Seringe referred to the cultivated varieties Abricotée, Mirabelle, Drap d'Or, and Abricotée-hative of Duhamel.[4] The citation of the first, Abricotée, is evidently an oversight, and incorrect, the same variety being given under the next head. Of these the Mirabelle seems to stand most clearly for the group in hand. This Mirabelle is not the Myrobalan known in this country and referred here to var. *Myrobalana*. Just what it is does not seem to be perfectly clear, though Koch[5] has discussed the distinction at length and Downing[6] describes and illustrates the variety separately. Nearly all the leading works on pomology give the Mirabelle similar treatment; and though I am at present unacquainted with any such variety,

[4] Direct references are given to Traité des Arbres Fruitiers **2**: 93, 95 and 96 and to op. idem, ed. nov. **5**: 195. Figures are cited carefully. This is true for all varieties.

[5] Deutsche Obstgehölze 151.

[6] Fruits and Fruit Trees of America, 282. 1847. [7th ed.]

it is not too much to expect that we may understand the characters of the group and presently find a modern representative of it. Seringe's characterization of the group was as follows: "Fructibus rotundatis flavis vel viridi-flavescentibus, nucleo obtusiusculo."

The figures usually represent a small plum, somewhat ellipsoid, and with an evident suture.

PRUNUS DOMESTICA CEREOLA.—The Reine Claudes, or Green Gages. This is one of the most distinct and important of all the groups mentioned, and one of the oldest. It seems to have been clearly understood as a separate group by all the early botanists, and is specially recognized in many of the herbals. It is particularly mentioned by almost every writer in Europe and America from the time of Bauhin to the present. A great deal of speculation has been spent on the problem of its geographic and genetic origin, but no finally defensible conclusion has been reached. Its birthplace may have been southern Europe or eastern Asia. Koch[7], who is one of our best authorities on these questions, advances the rather unlikely hypothesis that it originated from a crossing of the Zwetsche and the Damson, *i. e.*, *Prunus domestica galatensis* × *P. domestica damascena*. Our first definite knowledge of the variety, however, comes from Italy, where it was cultivated under the name of Verdochia. It was brought to France about 1500, the story being that it was introduced by Queen Claudia, wife of Francis I. Thus it took the name of Reine Claude. It came early to England, both from Italy and from France. The plums from Italy were grown in England under the name of Verdoch, and under that name are mentioned by Parkinson in 1629.[8] It was probably later than this that they were brought from France, at which time the labels were lost, and the variety was renamed Green Gage, a name which has followed it to America, and which is now the one best known both here and in Britain. American nurserymen have

[7] Deutsche Obstgeholze 150. 1876.

[8] This and divers other points in the history of the Reine Claude group are taken from Hogg, Fruit Manual 552. London. 1875. [4th ed.]

also imported several horticultural varieties of this group from France under the names Reine Claude, Reine Claude de Bavay, etc., so that we have both names still in common use. Poiteau, a most excellent student of pomology, remarks[9] that the Reine Claude is reproduced more or less true from seed, and the same statement is made elsewhere. The fact is still evident in the large number of seedling varieties in this country closely resembling the Reine Claude. All this justifies very well the work of Linnæus and Seringe, while holding to their notions of species and varieties, in making a separate variety of this group. We have dozens of modern representatives of this type. One catalogue which I consulted gave approximately 50 separate varieties, and 149 synonyms.

PRUNUS DOMESTICA MYROBALANA.—This is identical with Ehrhart's *Prunus cerasifera*, which is given as a distinct species in the revised *Field, Forest and Garden Botany*, and which will probably be generally accepted in this country. Linnæus' var. *acinaria* seems to belong here also, but this point cannot be determined with certainty.

PRUNUS DOMESTICA DAMASCENA.—The Damsons. This group is so distinct that it has often been given specific rank. If there were anything to be gained by it there is no reason why it should not be revived as a separate botanical variety at the present time. The Damsons as a class, come fairly true to seed, preserving their group characters quite well enough for ordinary purposes of classification. Var. *hungarica* of Linnæus is doubtless to be included in Seringe's var. *Damascena*. Var. *augustana* Linn., ought perhaps to fall into the same group, though it is very difficult to see just what Bauhin had in view in *Prunus Augusto maturescentia minora et austeora*. The name in the second edition of *Species Plantarum* was changed to *angustana*, but the derivation from Bauhin makes it clear that the earlier spelling is the one to be retained. Linnæus' variety *praecox* has been referred to this group still more doubtfully. It falls here by exclusion from the other groups, rather than by any positive characters of

[9] Pomologie Française (no page). 1846.

identity. The group of Damsons is numerously represented in American orchards of the present day.

PRUNUS DOMESTICA PERNICONA.—These plums have long been known in cultivation under the name of Perdrigons. Two hundred years ago they seem to have been as distinct and important as the Reine Claudes. The first edition of *Species Plantarum* gave this name *pernicona*. In the second edition it was changed to *pertigona*. As both names appear in the pre-Linnean synonymy of the group it is apparent that this change was entirely arbitrary. The earliest spelling is therefore to be retained.

None of the Perdrigons specifically so-called are in general cultivation in this country now, though Downing[10] describes White Perdrigon, Blue Perdrigon, Red Perdrigon, and some other varieties properly referred to the same group. It is possible that further study of existing horticultural varieties will point out some good types of this group; but for the most part the Perdrigons, as a definite type, seem to be lost from American gardens, though several of the old time varieties are still cultivated in Europe. Even those varieties like Goliath, Diamond, etc., which may perhaps belong here, are not favorites in this country. They appear to be generally large, round, coarse-fleshed fruits of poor quality.

PRUNUS DOMESTICA JULIANA.—The St. Julian plums, at the time when the *Prodromus* was written, were plainly understood to belong to a separate type. They seem largely to have disappeared, however, from modern horticulture. Downing does not give the name, even as a synonym. Neither does Thomas. Hogg[11] describes one St. Julian, and says that "it is scarcely ever cultivated for the fruit," but makes a good stock. The St. Julian is still used as a stock in some parts of Europe. It has been employed to some extent in this country, but proved insufficiently thrifty to suit American commercial nursery methods. Professor Bailey tells me that the St. Julian, as he has seen it recently in European nurseries, is to be referred evidently to *Prunus*

[10] Fr. & Fr. Trees Am. 287, 290, 312. 1847. [7th ed.]

[11] Fruit Manual 570. 1875. [4th ed., London.]

cerasifera; and the fact that it grows from cuttings and its use as a stock may be held to strengthen this view. However, it is perfectly plain that in the view of early botanists the St. Julians were more closely allied to the Damsons, from which they were distinguished by their more ellipsoid fruit.

PRUNUS DOMESTICA CEREA.—The St. Catherine plums form a considerable pomological group, and are fairly well represented at the present day. St. Catherine, still cultivated in some parts of America, is probably the same variety figured and described by Duhamel in 1768, and taken by Seringe as the type of his botanical variety *Catherinea*. Linnæus' var. *Brignola* perhaps also belongs in this group.

PRUNUS DOMESTICA AUBERTIANA.—It seems impossible to refer any one of Linnæus' varieties to this group of Seringe. Nor do any of the descriptions of Tournefort, Bauhin, or other early writers seem to suit. This is so very odd as to raise a fair doubt of our understanding, at this point, of the Linnæan classification. The plum, Dame Aubert, figured and described by Duhamel and (doubtfully) taken by Seringe for his type, was certainly old enough to have been known by Linnæus, and was altogether too conspicuous a thing to have been overlooked. The type is preserved to us in Magnum Bonum.

PRUNUS DOMESTICA GALATENSIS.—This group was evidently intended to include the prunes, a class of plums which has often been felt, especially in Europe, to stand by itself. The fruits are usually pyriform, with free stones, and are suitable for drying. Considerable confusion exists as regards the reference of many cultivated varieties to this group, but the type is fairly clear, permanent, and well understood. The common prunes of the Pacific states and the ordinary Italian Prune of eastern orchards may be taken as the modern representatives of the group.

I ought now to hasten to say that, in recalling the early views of these varietal types, I do not wish for a moment to recommend that they be revived for future use. Perhaps it would be worth while to resurrect the variety *Damascena*, but certainly botany has no use for the other variety names now, and horti-

culture is, I think, able to make a better classification out of fresh whole cloth. I have no doubt that a re-study and re-classification of the horticultural varieties of *Prunus domestica* would be a very proper and profitable thing at this time. If any one is inclined to attempt that work, this review of the early history of varietal types ought to be of some use.

In conclusion I wish to acknowledge my indebtedness to Professors W. W. Rowlee and L. H. Bailey for help in looking up these questions. The library of Cornell University has been of especial service.

UNIVERSITY OF VERMONT.

BRIEFER ARTICLES.

RECENT WORK UPON THE DEVELOPMENT OF THE ARCHEGONIUM.[1]

In a recent paper already reviewed in the GAZETTE,[2] M. L. A. Gayet has presented the results of an extended series of observations upon the development of the archegonium in the Muscineæ. These studies were pursued in part under the direction of Professors Van Tieghem and Flahault, and include the principal groups of Hepaticæ and Musci.

Having covered much the same ground in a work published nearly three years ago,[3] I have followed with much interest the results of M. Gayet's investigations. Inasmuch as these differ a good deal from my own observations in certain details of the development of the archegonium in both liverworts and mosses, I have examined again a considerable number of my preparations to see how far these would confirm the results obtained by Gayet.

Of the genera studied by Gayet, my own work included Riccia, Sphærocarpus, Targionia, Madotheca, and Anthoceros, all of which were examined in detail. On the other genera, Pellia, Marchantia, Preissia and Lophocolea, my own observations were either very incomplete or entirely lacking, but a number of other genera were included.

It has been generally supposed that the Hepaticæ differ radically from the Musci in the fact that the growth of the archegonium in the latter is mainly apical, while in the liverworts the growth in length is for the most part intercalary, the "cover-cells" of the archegonium being very early divided by intersecting quadrant walls. Gayet claims, in the first place, that he has demonstrated that this division does not take place until a late period, and that repeated segments are cut off from the cover-cell which add to the length of the neck; that is, in the

[1] GAYET, L. A.: Recherches sur le développement de l'archegone chez les Muscinées. Annales des Science Naturelles Bot. VIII. 3: 161–258. 1897.

[2] January 1898.

[3] Structure and development of the mosses and ferns: Macmillan, London. 1895.

Hepaticæ, as in the true mosses, the growth in length of the archegonium neck is in part apical. On the other hand, he maintains that, contrary to the generally accepted view, the moss archegonium does not have the canal cells of the neck cut off from the base of the apical cell, but they are the result of the division of a primary neck-canal cell as in the Hepaticæ. In short, he recognizes no essential difference in the type of archegonium in the two classes of bryophytes.

The first genus treated by Gayet is Riccia, of which he studied several species, including *R. glauca*. He does not, however, make it clear in his figures from which species the drawings were made. I have drawn from one of my slides of *R. glauca* a longitudinal section of the young archegonium which is shown in the accompanying *fig. 1*. It is perfectly evident that here the cover-cell has already undergone the quadrant divisions and no longer can function as an apical cell. The archegonium here figured is about the same age as the one figured by Gayet in *fig. 7* of his first plate. The occurrence of two resting nuclei in the terminal cell, without any trace of a division wall, shown by him in *fig. 5* of the same plate, is, to say the least, remarkable. It is extremely likely, however, that proper staining would have shown a vertical wall between them.

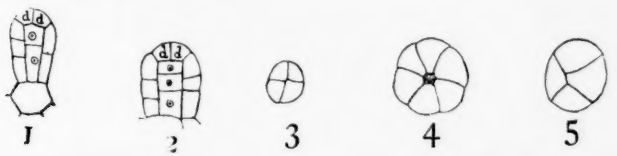

Fig. 1. Median longitudial section of the young archegonium of *Riccia glauca; d, d*, the cover-cells.— Fig. 2. A similar section of the archegonium of *Targionia hypophylla*.—Fig. 3. Transverse section of the four cover-cells of the young archegonium of Targonia.— Fig. 4. Cross-section of the neck of the archegonium of *Sphærocarpus terrestris*, var. *Californicus*, showing the six peripheral cells.— Fig. 5. The four cover-cells from a young archegonium of *Porella* (*Madotheca*) *Bolanderi*.—All the figures drawn with the camera from microtome sections.

The accompanying figures of the young archegonium of Targionia, *2, 3*, show that here too, the quadrant divisions of the terminal cell occur very early, and that any appreciable growth in length of the neck due to the activity of an apical cell is out of the question.

Of all the forms examined by me, the one which approached nearest the condition described by Gayet was *Porella* (*Madotheca*) *Bolanderi*.

While in this species there is an early quadrant division of the cover-cell (see *fig. 5*), the four resulting cover-cells are larger than is usually the case, and there may apparently be a limited number of the outer neck-cells which are cut off from these cells. Such a case is shown in *fig. 46, E*, of my *Mosses and Ferns*. That the cover-cells of the liverwort archegonium may undergo one or two divisions subsequent to the original quadrant-divisions, has been long known, but I have been unable to convince myself that any apical growth, in the sense in which it is understood among the true mosses, can be demonstrated in any of the liverworts examined by me.

Six rows of peripheral neck-cells are regularly found in the archegonium of the Marchantiaceæ while the normal number is five in the Jungermanniaceæ. I have found that in *Sphaerocarpus terrestris* var. *Californicus* and the allied Geothallus, there are six rows of peripheral neck-cells, in which respect, as well as others they are intermediate between the Ricciaceæ and thallose Jungermanniaceæ. Gayet disputes the accuracy of my statement in regard to Sphærocarpus, and it is possible that the European form of the species may show but five rows of cells. Neither of the two figures of Sphærocarpus shown by Gayet is a cross-section, nor does he say whether he actually examined such sections. In the few cross-sections of the archegonium neck which I have made, the number of cells was six (see *fig. 4*), although it is possible that this number may not always be constant.

It is to be regretted that M. Gayet has not given a more detailed account, as well as additional figures, of the archegonium of the thallose Jungermanniaceæ. He finds that in Pellia, as well as other Anacrogynæ, there may be six rows of peripheral cells, instead of the usual five rows hitherto supposed to be constant in this group, aside from Sphærocarpus and Geothallus. It is not strange that these primitive forms should show this approach in their structure to the Ricciaceæ with which they are closely connected by Sphærocarpus. It is to be hoped that we may soon have further information on this interesting point.

In regard to the statement that in the Musci the neck canal-cells are not cut off from the base of the terminal cell, as has been hitherto supposed, it cannot be said that Gayet's figures are very convincing. This very difficult point can only be settled by means of very thin axial sections of young archegonia. Here, too, a proper staining of

of the division walls, such as M. Gayet seems to have considered superfluous, is very essential.

In studying M. Gayet's technique it is evident that he has depended too much upon rather primitive methods. While he has had recourse to various fixing and staining agents, he admits that so far as possible he has depended upon free-hand sections or "dissociation," *i. e.*, the dissection with needles of material treated with a strong macerating fluid. Where objects were too small to be thus handled they were imbedded in celloidin, which was then included in a coating of glycerine-soap. He does not appear to have employed paraffin for imbedding, nor to have employed any but nuclear stains, and it is very evident from some of his figures, *e. g.*, *5*, *83*, that cell-walls were in some instances entirely overlooked. In my own studies of the archegonium I have found such thin serial sections as can most readily be made by the paraffin method indispensable, and some good stain for the cell-walls, like Bismarck-brown, is necessary in order to differentiate the young cell-walls. The doubtfulness of conclusions drawn from a study of optical sections alone, from material rendered transparent by potash or other clearing agents, need not be insisted on here.

In short, until some of the statements made by M. Gayet can be confirmed by a thorough study of properly stained serial microtome sections, his conclusions can hardly be accepted without a certain amount of reservation.— DOUGLAS HOUGHTON CAMPBELL, *Leland Stanford Junior University.*

THE HOMOLOGY OF THE BLEPHAROPLAST.

THE recent investigations upon plant spermatozoids have not only added immensely to our knowledge of the structure and development of these organisms, but have brought out interesting suggestions as to the homologies of certain structures.

Previous to 1894, writers were concerned largely in discussing whether the body of the spermatozoid consisted of nucleus alone, or of both nucleus and cytoplasm. All agreed that the cilia are developed from the plasma. Later contributors, Belajeff, Hirasé, Ikeno, Webber, Shaw and Fujii, have shown conclusively that the body of the mature spermatozoid consists of both nucleus and cytoplasm; and, further,

all connect the formation of cilia with definite organs which are variously designated Höcker, Körnchen, Körperchen, Nebenkern, attraction sphere, directive sphere, centrosome, centrosome-like body, and blepharoplast. It may safely be assumed that the various writers would now agree that the body described under so many names is the same morphological structure in all the forms studied. In this sketch Webber's peculiarly appropriate term blepharoplast will be used, disregarding the terms used by the various writers.

In *Equisetum arvense*, according to Belajeff, there appears in the mother cell of the spermatozoid not only the cytoplasm and nucleus, but also a deeply staining body resembling a centrosome. This body stretches into a thread lying along the nucleus. The thread becomes differentiated into a row of granules (Höcker), each of which gives rise to a single cilium. In the fern, *Gymnogramme sulphurea*, in the cell which is to give rise to two spermatozoid mother cells, Belajeff figures two blepharoplasts at opposite poles of the nucleus, giving a very centrosome-like aspect, but the blepharoplasts do not divide like Guignard's centrosomes, and each spermatozoid mother cell receives but a single blepharoplast. The further history of the blepharoplast is essentially the same as in Equisetum. It is suggestive to note that in Chara there are two *Höcker*, each of which gives rise to a single cilium.

Shaw's figures of *Marsilea vestita* might lead one to infer that the blepharoplasts have some relation to nuclear division, their position at the poles giving them a very centrosome-like appearance; but we are assured that there is no ground for the assertion that blepharoplasts are homologous or analogous with the centrosomes of those plants which have centrosomes, and that whether they have any relation to the centrosomes of lower plants must be settled by an investigation of the spermatogenesis and zoospore formation of these plants. Shaw did not succeed in determining the origin of the cilia, but believed it to be as described by Belajeff for Equisetum.

The blepharoplasts of Gingko, Cycas, and Zamia are of gigantic size in comparison with those already mentioned. In these three forms, as in the cryptogams mentioned above, the blepharoplast stretches out into a band which gives rise to the cilia. Hirasé's figures and descriptions of Gingko show that the blepharoplast is surrounded by kinoplasmic radiations in nearly all stages of its history. Two blepharoplasts first appear at opposite poles of the nucleus of the body

cell and during mitosis maintain a position at opposite poles of the spindle, although at some distance from the spindle and from the daughter nuclei after division has taken place. Judging from the figures, one might conclude that, while the blepharoplasts do not appear to be concerned in the formation of the spindle, they may perhaps determine its orientation. As a matter of fact, the wall between the daughter nuclei is at right angles to a line connecting the two blepharoplasts. Belajeff's figures of Gymnogramme and Shaw's of Marsilea show the same orientation. Hirasé believes that the blepharoplast is a centrosome.

Ikeno's description of blepharoplasts in *Cycas revoluta* agrees in general with Hirasé's account of Gingko. After reviewing Hermann's work on the spermatogenesis of the salamander and the mouse, Ikeno comes to the conclusion that the blepharoplasts of the Characeæ, Filicineæ and Equisetaceæ, and also those of Gingko, Cycas and Zamia, not only bear a superficial resemblance to centrosomes but are genuine centrosomes which become enormously elongated and furnish a place of attachment for the cilia. Belajeff had previously reached a somewhat similar conclusion, although it was left for Ikeno to formulate it. Belajeff homologizes the blepharoplast of Characeæ, Filicineæ and Equisetaceæ with the deeply staining body of the spermatid of the salamander and the mouse, while the middle piece of the animal spermatozoon corresponds to the elongated cilia-bearing band of the plant spermatozoid. The thread-like tail of the spermatozoon of the salamander and mouse corresponds to a single one of the cilia of the plant spermatozoid.

The blepharoplasts of *Zamia integrifolia* described by Webber are the largest yet discovered. Webber does not believe that they are centrosomes. It may be true that they take no part in the formation of the spindle, but an examination of the figures forcibly suggests that they either orient the spindle or are oriented by it.

The centrosome of the alga Dictyota, recently described by Mottier, becomes elongated into a band which gives rise to cilia-like radiations. Mottier, as will be remembered, declares that in the higher plants there are neither centrosomes nor centrospheres in vegetative or reproductive cells, whether in the resting condition or during division, and he further asserts that there are no bodies which have any resemblance whatever to these structures or which stand in any relation whatever to karyokinesis. In the paper on Dictyota, Mottier, referring to the

blepharoplasts of higher plants, states that they have nothing to do with spindle formation, a more conservative statement which, though probable, still remains to be proved, and even if proved determines no homologies.

It is readily admitted that the presence of centrosomes is not established in any of these plants which have such conspicuous blepharoplasts, and that the blepharoplasts are reported only in the last two generations of cells concerned in the formation of the spermatozoid; but it must also be admitted that the usually spherical centrosome may in certain cases assume other shapes, and that an increasing number of competent observers do not regard the centrosome as a permanent organ of the cell. Furthermore, the absence of the centrosomes from the higher cryptogams and the flowering plants is far from being established, and a most convincing demonstration is necessary before the testimony of Guignard, Rosen, Campbell, Schaffner and others can be disregarded.

If our conception of the centrosome is formed exclusively from the familiar figures of karyokinesis and the function of the centrosome in this process, we shall doubtless look for a new name whenever we find a centrosome-like body performing any other function than that of the typical centrosome; but it seems probable that a thorough investigation of karyokinesis and the formation of cilia in the lower plants may support the theory that the blepharoplast is a centrosome. —CHAS. J. CHAMBERLAIN, *The University of Chicago.*

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OPEN LETTERS.

ANOTHER QUESTION OF NOMENCLATURE.

THE receipt of Mr. G. B. Sudworth's *Check-List of the Forest Trees of the United States* (U. S. Dept. Agriculture), stirs me up to make a protest against a nomenclatural heresy which seems to find favor in certain quarters. It is this: *that a varietal name must be changed if it occurs elsewhere in the genus, even as the name of another species, or of a variety of another species.* This doctrine does not seem to me to be justified by the codes, nor is it conducive to the stability of varietal names. I have for many years had a good deal to do with the varietal nomenclature of animals, particularly mollusca, and have always considered it commendable to give the same name (*e. g.*, *minor*, *alba*, *elongata*, *hirsuta*, etc.) to similar variations of different species. This plan is widely accepted among zoologists, and is found advantageous in every way. The first time I noticed any general application of the contrary plan was when I received Bull. 9 of the *Minnesota Botanical Studies*. In this work (1894) Mr. E. P. Sheldon proposes ten varietal names in Astragalus, all of which I consider quite needless. Mr. Sudworth, in his *Nomenclature of the Arborescent Flora of the United States* (1897), and again in the above-mentioned *Check-List*, has followed the same doctrine, and has made sixty-six substitutions of new names for old, which I think should not be accepted. He has also made a number of other substitutions which rest on other grounds, and are apparently valid.

It is particularly important to decide at this time what we are going to do about the doctrine here discussed, because Mr. Sudworth has very excellently prepared a revised nomenclature of the cultivated varieties of our native trees, and unless some protest is made, it will doubtless become current as it stands. The desirability of a correct nomenclature for cultivated plants need not be urged, nor need it be pointed out that it must be for botanists to decide, eventually, what system shall be adopted. The system introduced by Mr. Sudworth, if supported, will logically compel us to make a revision of varietal nomenclature in many other groups, productive of much inconvenience, and, as I believe, of no good.

I append herewith a list of the Sheldonian names in the work cited, which I would reject, giving the corrected nomenclature in the second column. I have also prepared a list of the Sudworthian names, but it is too long to print here.

Other similar instances may be found in the *List of Pteridophyta ana Spermatophyta in Northeastern North America* (1894), particularly under *Carex*.

A reasonable rule, which would avoid these changes, would be: *Only identical combinations shall be considered homonyms*.

NAME PROPOSED BY SHELDON.	CORRECT NAME ACCORDING TO PRESENT WRITER.
Astragalus viridis impensus.	*A. v. elatus* (Wats.).
A. speirocarpus curvicarpus.	*A. s. falciformis* A. Gray.
A. preussii laxispicatus.	*A. p. laxiflorus* A. Gray.
A. p. arctus.	*A. p. latus* Jones.
A. leucopsis curtus.	*A. l. brachypus* Greene.
A. franciscanus longulus.	*A. f. virgatus* (A. Gray).
A. megacarpus prodigus.	*A. m. parryi* A. Gray.
A. sparsiflorus majusculus.	*A. s. major* A. Gray.
A. glabriusculus spatiosus.	*A. g. major* A. Gray.
A. atratus arctus.	*A. a. stenophyllus* Jones.

It will be noted that Mr. Sheldon himself gives the same varietal name to two species. This may be an oversight, or it may be that he considers a varietal name invalid only when used (if not under the same species) in a specific sense elsewhere in the genus. At the same time, he changes a varietal name when the alleged homonym is a pure synonym, so long as it is a binomial.

A curious case is that of *A. crotalariæ* var. *virgatus* Gray. It seems that both names are preoccupied in a specific sense, so Sheldon calls the species *A. franciscanus*. According to my views, Gray's varietal term *virgatus* may be retained *as varietal*, though it cannot be applied to the species, because of the earlier *A. virgatus* Pall. Thus we get *A. franciscanus* var. *virgatus*, an instance of a varietal name older than that of the species.—T. D. A. COCKERELL, *Mesilla Park, N. M.*

CURRENT LITERATURE.

BOOK REVIEWS.

The organography of plants.

A FEW months ago we had the pleasure of receiving the first part of Goebel's *Organographie der Pflanzen*. The hope that was then expressed[1] is now in a measure realized by the publication of the first section of the second part.[2] This section is devoted to the bryophytes. In the general part the author sought to picture the fundamental principles of organ formation, illustrated by a few examples. In the special part he seeks to carry out the plan in greater detail, so far as concerns the archegoniates and seed plants.

At the outset he meets the question, "in what relation organ formation stands to adaptation, or, in other words, whether the specific characters which separate the individual species, genera, etc., in any order, are of an adaptive nature only, as the extreme believers in the importance (*Bedeutung*) of natural selection think, or whether specific and adaptive characters are to be distinguished." Goebel expresses the positive conviction that the latter is the case, holding that, although "organization must, of course, always meet the life demands, the characteristic impress which it bears in every group, in spite of all the variety in the special adaptive external conformation, shows that the 'inner constitution'—if we may use this expression to hide our ignorance—plays the most important rôle, even were the polymorphism of organ formation not comprehensible." When, however, an adaptive character appears in all, or almost all, the members of the group, *e. g.*, the thallus structure in Marchantiaceæ, there arises a difficulty which the author dismisses with these words: "this is to be considered more than an accidental coincidence with the specific characters; an agreement, indeed, which one can make thoroughly intelligible only when one supposes the adaptation to be ancient, having taken place before there occurred a separation of the group in question into forms developing in different directions." This, of course, one of those "extreme believers in the importance of natural selection" (from whose ranks Goebel excludes himself), would call a begging of

[1] See review in this journal, **25**: 290. 1898.

[2] GOEBEL, K.—Organographie der Pflanzen, insbesondere der Archegoniaten und Samenpflanzen. Zweiter Teil: Specielle Organographie. 1 Heft: Bryophyten. 8vo. pp. 283–385. *figs. 131–359*. Jena: Gustav Fischer. 1898. *M* 3.80.

the question! Is it conceivable that the "inner constitution" is anything more than the aggregate result of ancient adaptations?

Here is another sentence which seems to strike a false note in its implications. "All speculations, proceeding from the highly developed archegoniates, as to the connection of liverworts and mosses, bryophytes and pteridophytes, etc., are, therefore, only products of the poetic imagination, arising from our mental necessity of assuming connections even where they cannot be directly observed, but having no adequate support in the facts of experience. Their sole value consists in that they incite to the raising of new questions." What higher value, we may ask, has any hypothesis?

We shall have concluded all adverse criticism when we further point out that in this section, much more than in the general part, the author yields to the seductive temptation to assign definite purposes to certain organs, and to say: this is an adaptation for thus and so, with the same airy grace to which we have become accustomed in Haberlandt's *Physiologisches Pflanzenanatomie*. One can hardly help thinking, like Cato, "It must be so: Plato, thou reasonest well; else, whence this. . . . ." Yet, all the while, there is a subconscious certainty that the solution is too easy, and that, in some measure at least, we are listening to fairy tales — "lediglich Produkte dichterischer Phantasie," to use the phrase Goebel has given us. We are unpleasantly reminded of the outgrown teleology by this new attempt to explain

> The reasons of things —
> Why Injuns wore rings,
> In their red aboriginal noses.

We cite only one example (p. 242): "I entertain no doubt that the mucilage filling the neck-canal [of the archegonium] protects the egg chiefly against contact with water." Can one avoid asking evidence that there is need for protection of the egg against contact with water, and, if that is furnished, demanding proof that water movement is restricted by this mucilage when it is not by other kinds?

But it is in the clear stream that one discerns the snags along its bed, while turbid waters hide their dangers. On the whole, this section of the work is, like its predecessor, most interesting, suggestive, and valuable. The new point of view for the discussion of the bryophytes is the striking feature. We have grown used to the purely formal standpoint — even to the *Standpunkt der Mikrotomtechnik* — which, the author well declares, "is greatly inferior to the apprehension of nature by the great bryologist of the preceding century, Hedwig, whose view was not yet narrowed by the verbal blinders, morphology and physiology." And so the facts which the author sets before us are presented in a new light. Seen in this way they are certain to suggest new investigations. No higher result can be sought or obtained from such a book, and none so sure to redound to the permanent fame of the author.

Moreover, the book is far from a review of already published facts. It sets before the reader a great number of new investigations of much interest, illustrated by many new figures, whose freshness is as invigorating as a sea breeze. To one who restates in better form our old knowledge, and adds so much that is new, it is easy to forgive the possible slight distortion of perspective which we shall easily escape when at a greater distance from the facts. It is only bare justice to recognize in this work a master hand, and to hail it as one of the books predestined to become a classic. — C. R. B.

A new school botany.

IT is a good sign when university professors interest themselves in secondary education. Too often text-books for high schools have been prepared by those who do not know the subject; and it may be further stated that occasionally text-books have been prepared by college men who do not know the schools. That happy combination of experience which brings together the two kinds of knowledge is demanded for the preparation of such books.

Almost every university will be represented presently by a botanical text-book for the secondary schools. In the opinion of the reviewer, the chief criticism to offer in reference to most of these books is that they attempt to present too great an abundance of material, and also material that is too difficult. It is hard for the average college man to appreciate how unfamiliar the material of modern botany is to the young student of the secondary school. A rapid succession of facts, all of which are new to his experience, is too apt to result in bewilderment rather than knowledge.

The last candidate in this field is from the pen of Professor Atkinson,[3] of Cornell University, who shows an appreciation of the situation, and who has certainly had a large and successful experience with elementary classes. The book is a hard one to criticise, as it is a combination of commendable and careless features. Some of the features that should receive warm commendation are wealth of illustration, short paragraphs with distinct headings, originality of presentation, and especially the ecological chapters upon soil formation, zonal distribution, and occupation of land. Certainly so many commendable features more than justify the publication of the book.

On the other hand, carelessness of statement and want of logical organization are apparent. This carelessness amounts frequently to error. The lack of organization is indicated on the surface by such facts as that the division of the book devoted to physiology has received no title and part number, such as have been given to Morphology and Ecology; and that the matter included

[3] ATKINSON, GEORGE FRANCIS. — Elementary Botany. Small 8 vo. pp. xxiii + 444. *figs. 509*. New York: Henry Holt & Co. $1.25.

under the various headings is frequently not what the heading indicates, as, for example, Chapter XII. This fault culminates in the division of the book given to ecology, which is in a remarkably indefinite condition.

It may be that an occasional lapse into poetical style has its place in stimulating interest in the secondary schools, but the reviewer questions whether a sentimental interest should have any connection with scientific training.

The introduction of photographs of typical plant associations is very commendable, but something must be done to make such photographs significant. This criticism has reference not only to the book in hand, but to the general use of such pictures. If ecology is to take the prominent place in elementary botanical education that it deserves, we must have publishers get beyond the dim and hazy landscapes which may be capable of interpretation by the trained ecologist, but which mean little or nothing to the elementary student.

Professor Atkinson's book is one of great interest, and will be a stimulus to proper botanical study in secondary schools. The weak points are such as often appear in the work of a very busy man, who may not lay special stress upon logical presentation and exact statement.—J. M. C.

Bokorny's text-book.[4]

THIS is the latest contribution to the long list of German text-books. It is intended for use in the technical schools and gymnasia, and seeks to present the subject without requiring of the student too great "expenditure of time or effort of memory." To this end a novel approach to the subject is introduced. Thirty-five pages are devoted to the illustrated descriptions of some of the commonest seed plants, the violet, mustard, pear, etc. These descriptions are in the simplest language, and are evidently intended to be taken in connection with laboratory study of the types selected. However remote such an approach may be from a logical presentation of the subject, there is some reason in the plea that the student may be thus gently induced to careful observations, and well oriented in the new field by learning first the technical interpretation of the plants he has always known. The rest of the text suggests an effort to give good place to each of the schools with too great emphasis upon none. It is an exemplification of the extremely various ideas which prevail as to which interpretation of the plant world may best be presented first to the beginner. The author, save for the departure in the first chapters, does not commit himself. The organs of the plant body are taken up in logical sequence in the second part. This would serve equally

[4] BOKORNY, TH.—Lehrbuch der Botanik. 8vo. pp. vi + 226. *figs.* 170. Leipzig: Wilhelm Engelmann. 1898. *M.* 2.40.

well morphology, taxonomy, ecology, physiology, what not. Then a few pages are devoted to minute structure, and a review of forms follows with the highest spermatophytes leading the procession, and in the usual modern proportion of about four pages of spermatophytes to one of the "sporophytes" (the author's word).

The physiology is divided into the chemical and physical processes within, and the "biology," *i. e.*, relations to environment; a separation not without difficulty. Three pages are devoted to "something about plant geography," and a key for identifications completes the work. The text is exceptionally clear, simple, and free from technical phraseology. Most of the illustrations are borrowed from the *Natürlichen Pflanzenfamilien*, which is sufficient commendation.—JOHN G. COULTER.

MINOR NOTICES.

THE WRITINGS of Professor Dr. P. Magnus, of Berlin, include much matter that is of moment to American botanists. Dr. Magnus is a student of fungi, but writes to some extent upon other subjects. His interests are catholic, and he has often contributed to the solution of problems arising in distant quarters of the globe. A number of separates (which he generously sends to all whom he knows to be interested in such subjects) have recently come to hand, and the opportunity is taken to give a brief account of their contents.

In a communication to the *Botanisches Centralblatt*[5] some criticisms are offered upon the treatment given the Hemibasidii and Uredinales by Dr. Dietel in Engler and Prantl's *Natürliche Pflanzenfamilien*. It is pointed out that the sorus of Doassansia is never imbedded in the parenchyma of the host, as stated by Dietel (*l. c.*, p. 21), but always lies immediately beneath and in contact with the epidermis. He reviews the genera Doassansia and Burrillia and their subgenera as characterized by Setchell, and holds them to be more logical and natural than the arrangement proposed by Dietel. Turning to the Uredineæ he states that *Puccinia Schweinfurthii* Magn. forms witches' brooms, and should not be confounded with *P. Mesneriana* Thüm. or *P. digitata* Ell. & Hark., which never do so, although otherwise much alike. Exception is taken to the establishment of the genus Phragmopyxis with a layer around the spores that swells in water, while ignoring Schröter's genus Uropyxis with just the same claim to recognition. It is pointed out that aside from this equivocal character, Uropyxis possesses good generic characters in the number and position of the teleutosporic pores. The suppression of the genera Xenodochus and Chaconia, and the grouping of some of the genera are not approved.

[5] Einige Bemerkungen zu P. Dietel's Bearbeitung der Hemibasidii und Uredinales in Engler-Prantl Natürliche Pflanzenfamilien Bd. I.—Bot. Centr. **74**: 165–170. 1898.

An extended account of the structure and occurrence of some new species: *Phleospora Jaapiana*, from Germany,[6] *Aecidium Opuntiæ* from Bolivia,[7] and *Aecidium Jacobsthalii-Henrici* from the Straits of Magellan,[8] with fine detailed illustrations in each case, gives much information beside the usual diagnoses.

In 1897 Dr. Magnus traveled in the United States, and he took the opportunity to make observations upon the lilac mildew[9] so familiar to everyone in this country, and especially to all pupils in college classes in botany. In Europe the lilac is free from mildew, only one collection being recorded, and that proved to be *Microsphæra Ehrenbergii* Lev., a common species on *Lonicera tartarica*. The American form was for a time referred by American botanists to *M. Friesii* Lev., but since the study of it by Burrill in the preparation of his article on the Parasitic Fungi of Illinois, it has been called *M. Alni* (DC.) Wint. Dr. Magnus shows that although it is very closely related to *M. Alni* of Europe, yet there are some morphological differences which indicate that it is geographically modified, and entitled to a separate name. Priority requires that it be called *M. Syringæ* (Schw.) Magn., which he considers unfortunate in view of the fact that the American forms upon Betula, Corylus, Castanea and Ilex must also be placed under it, all being native plants while Syringa is introduced, and is therefore a comparatively recent host for it. Attention is called to the fact that so far no cultural studies have been made among the Erysipheæ to determine relationship.

While in this country Dr. Magnus read a paper at Toronto before the British Association for the Advancement of Science upon the mycelium of witches' brooms of the barberry[10] in Europe. It had been asserted by Eriksson that the mycelium of this Aecidium penetrates the cells of the host, and develops colored granules within, both being exceptional for members of the Uredineæ, but both claims are shown to be errors. This is the Aecidium of *Puccinia Arrhenatheri* (Kleb.) Eriks.

In a short communication to *Hedwigia* on *Puccinia Lycii* Kalchbr.,[11] some errors in the original description are noted, and also an increase in the number of pores of the uredospores corresponding to an increase in size.

[6] Eine neue Phleospora. Hedwigia **37**: 172–174. 1898.

[7] Eine neues Aecidium auf Opuntia sp. aus Bolivia. Ber. d. deutsch. Bot. Ges. **16**: 151–154. 1898.

[8] Ein auf Berberis auftretendes Aecidium von der Magellanstrasse. Ber. d. deutsch. Bot. Ges. **15**: 270–276. 1897.

[9] Der Mehlthau auf *Syringa vulgaris* in Nordamerika. Ber. d. deutsch. Bot. Ges. **16**: 63–70. 1898.

[10] On *Aecidium graveolens* (Shuttlew.). Ann. Bot. **12**: 155–163. 1898.

[11] Ein kleiner Beitrag zur Kenntniss der *Puccinia Lycii* Kalchbr. Hedw. **37**: Beiblatt 91–93. 1898.

The teleutospores are also exceptional in having the pore of the lower cell at the bottom rather than in the upper part.

Two articles before us are of local interest,[12] but another, the last to be mentioned, brings out the interesting fact that the production of lateral flowering stems from the base of the common century plant, *Agave Americana*,[13] when the central shaft has been injured, was recorded as early as 1705 —J. C. A.

THE ADVISABILITY of using pure cultures of yeasts in the process of fermentation in breweries has been clearly demonstrated by a number of writers. It has been suggested frequently that the same purity of yeasts is no less desirable in the manufacture of bread, and in order to determine whether this is true, Miss Katherine E. Golden has made a study of several commercial yeasts and their effects.[14] It was found that almost all market yeast packages contain corn or potato starch; and that they are adulterated with alum which is added as an antiseptic against bacteria and molds. The bacteria were constantly present, however, and the molds in many of the packages. These greatly change the fermentative effect of the yeasts, and produce unpleasant odors which are indications of the less nutritious condition thus induced in the bread.

Experiments were made to test the efficiency of various commercial yeasts, and of pure cultures made from the same. It was found that young cultures of pure yeast would bring a much greater fermentation in bread sponge in less than half the time required by ordinary market yeast. With such pure cultures the desired fermentation within the sponge is secured before there has been sufficient time for undesirable organisms to develop. This is not true with the yeasts usually employed, since by waiting for the necessary fermentation there occurs frequently a large and injurious growth of bacteria and molds which begin to induce putrefaction in the sponge. When pure and vigorous yeasts were used the bread was always sweet, and remained good much longer than when made with the adulterated cake. The flavors of good bread may be varied by the use of various kinds of yeasts. If the same care is used in this manufacture as is used in the

[12] Zweiter Beitrag zur Pilz-Flora von Franken. Abh. d. Nat. Ges. Nürnberg **11**: 23–57. *pl. 1.* 1898.

Ein weiterer Beitrag zur Kenntniss der Verbreitung der *Thorea ramosissima* Bory im mittleren Deutschland. Deutsch. Bot. Monatssch. **1898**: 17–18.

[13] Blühen der Agaven an Seitentrieben, von Dr. Otto Kuntze. Mit Bemerkungen zu den vorhergehenden Mittheilungen, von P. Magnus. Gartenflora **1898**: 215–216.

[14] GOLDEN, KATHERINE E.—(1) Yeasts and their properties. 8°. pp. 28. (2) On bread and bread-making. 8°. pp. 22. Purdue University Monographs; Series relating to food, nos. 5 and 6. 1898. (3) Pure yeast in bread. Proceedings of Indiana Academy of Science **1897**: 62–64. 1898. (Reprint repaged!)

selection of yeasts for the manufacture of beer and other liquors, a very much finer quality of bread may be secured, and many deleterious effects may be avoided.

Further work was done to determine whether the yeast cells live in bread after baking, and the conclusion was reached that yeasts are always killed by the heat necessary to bake the bread. If living yeast cells were taken into the alimentary canal, however, they would probably produce no bad results as experiments made seem clearly to demonstrate.

The papers contain most careful and interesting descriptions of the many kinds of bread and the best processes of making them.—OTIS W. CALDWELL.

THE FLORA of Costa Rica has been receiving its share of attention, the results appearing in parts under the title *Primitiæ Floræ Costaricensis*. Parts I–III were published at Brussels in 1891, 1893, and 1896, respectively, under the joint direction of Th. Durand and H. Pittier. These three parts completed the first volume, and at its close M. Durand was compelled to withdraw from the undertaking. The first part of the second volume has now appeared,[15] published at St. José de Costa Rica, under the auspices of the National Geographical Institute, and with M. Pittier as sole editor. Mr. J. Donnell Smith has contributed the part by preparing a list of the known Polypetalæ, including descriptions of new or recently described species, and omitting those families which have been presented in previous parts. It is a great gratification to those interested in the American tropics that this important publication is to be continued.—J. M. C.

PROTOPLASMIC streaming in Characeæ has been again investigated and is discussed from a strictly physiological point of view by Dr. Georg Hörmann in an extended paper, independently published.[16] He seeks a theoretical explanation of the movement of streaming and the conduction of impulses. An explanation of the direction and plane of streaming, both in cells of the axes and rhizoids, Hörmann finds in the advantage of securing the shortest route from the places of absorption or manufacture to the places of utilization of the materials, which thus, in their transfer, are subject to a minimal loss. The larger part of the paper is devoted to a discussion of experiments to ascertain the causes and nature of the movement, and the conduction of stimulation impulses. In his experimental work the application and ingenious adaptation of the modern methods of animal physiology yield new and valuable suggestions as to the theory of movement.

[15] PITTIER, H.—Primitiæ Floræ Costaricensis. Vol. II, pp. 1–126. Polypetalae. by John Donnell Smith. San José de Costa Rica. 1898. $1.00.

[16] HÖRMANN, GEORG.—Studien über den Protoplasmaströmung bei den Characeen 8°. pp. iv + 79. *figs. 12.* Jena: Gustav Fischer. 1898. *M* 2.

Finding that, just as in muscle and nerve, the nitella cell may be stimulated by the production of katelectrotonus and the disappearance of anelectrotonus and that the stimulation wave is accompanied by the so-called "negative" wave, he concludes that muscle, nerve, and nitella cell must have some fundamental structural element in common. As the nerve has only conductivity he concludes that conductivity and contractility are properties of different substance. The conductive plasma, existing alone in the nerve, is accompanied in muscle and nitella cell by another substance, which conditions the phenomena of contraction and streaming. Nor has he overlooked the difference between muscle and nitella, in that a stimulus in the one case causes a resting organ to work, while in the other it brings a working organ to rest.

The explanation of this is to be found only in a fundamental difference in the structure of the mechanism of movement. The details of the discussion must be sought in the work itself.—C. R. B.

DR. P. SYDOW has brought together much useful information in a botanical calendar.[17] Besides the astronomical calendar, there is a calendar for notes and memoranda for each day, with the birth and death days of many distinguished botanists; tables of equivalents in money, weights, and measures; post and telegraph rates; the Berlin rules for nomenclature; a list of the cryptogamic exsiccatæ which have been issued; a list of the botanic gardens and museums; and finally a list of the botanical collections to be found in the larger museums and herbaria. The difficulty of securing accuracy and completeness in the last three lists is very great. The author realizes that it has not been attained and appeals for assistance by corrections.—C. R. B.

A VERY USEFUL ACCOUNT of the economic grasses, by F. Lamson-Scribner, has been published as Bulletin 14 of the grass and forage investigations of the Division of Agrostology, Department of Agriculture. Brief descriptions and illustrations are given of the more important economic grasses of this country, or those which have been introduced because possessing some merit. Bulletin 15 of the same division is a report upon the forage plants and forage resources of the Gulf states, by S. M. Tracy, containing descriptions, comments, and illustrations, in addition to the general discussion of the forage problems of the south.—J. M. C.

F. H. KNOWLTON has done botanists great service in the preparation of his *Catalogue of the Cretaceous and Tertiary plants of North America*.[18] The

[17] SYDOW, P.—Deutscher Botaniker-Kalender für 1899. 16mo. pp. 198. Berlin: Gebrüder Borntraeger. 1898. *M* 3.

[18] KNOWLTON, F. H.—Bulletin of the U. S. Geological Survey no. 152. pp. 1–247. Washington, 1898. 20 cents.

first catalogue of the kind was that of Lesquereux, published more than twenty years ago, and containing 706 species. The present catalogue testifies to the fact that since that time species have been described with great industry. Although no statement is given as to the number of species, it is remarked that the Potomac flora alone now numbers more than the total Cretaceous and Tertiary floras known to Lesquereux. The catalogue is a real bibliography and must prove of great service.—J. M. C.

NOTES FOR STUDENTS.

H. H. DIXON has turned his attention to transpiration, and in Proc. Roy. Irish Soc. III. **4**: 618–635. 1898 discusses the effects of stimulative and anæsthetic gases on transpiration, and transpiration into a saturated atmosphere. —C. R. B.

CZAPEK points out[19] an interesting case of adaptation in leaves of *Cirsium eriophorum*. Plants growing in very sunny situations on the southerly mountain slopes in central Bohemia had the segments of their pinnatifid leaves erected into two comb-like rows, while in shady places these are transverse. The erect segments of the sun-beaten leaves were inrolled at the edges and were different in structure from the shade leaves, having palisade cells 25 per cent. longer, and richer in chlorophyll. The same difference was remarked between the erect segments and transverse portions of the same leaf.—C. R. B.

THE CYTOLOGY of the yeast cell has been a difficult matter to investigate, but important results have been obtained by Janssens and Leblanc.[20] They used malachite green, dahlia, gentian violet, Delafield's hæmatoxylin, and "black hæmatoxylin" (black hæmatoxylin differs from Delafield's in that the ammonia alum of the latter is replaced by iron alum). These stains show that every yeast cell contains a nucleus and a nucleolus. During budding there is indirect division of the nucleus in some species, while in the common *Saccharomyces cerevisiæ* and some others the division is direct. Cells about to produce spores contain two nuclei which fuse. The resulting spore on germination shows a much modified form of division. The paper is illustrated by excellent plates.—CHAS. J. CHAMBERLAIN.

UNDER THE TITLE *Analecta bryographica Antillarum* Dr. Karl Müller-Halle has published[21] a long list of mosses from the Greater and Lesser

[19] Œsterr. bot. Zeit. **48**: 369–371. 1898.

[20] JANSSENS, FR. A. and LEBLANC, A.— Recherches cytologiques sur la cellule de levure. La Cellule **14**: 203–343. 1898.

[21] Hedwigia **37**: (2–?) 266. 1898.

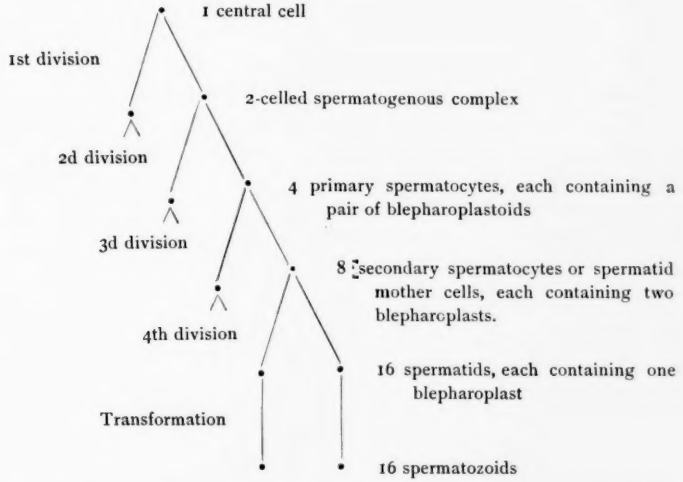
Antilles, a publication which has special interest in view of the botanical collections now being made in Cuba and Porto Rico. These "crumbs" Müller has swept up from various collections, some as old as Charles Wright's (1856). He enumerates 175 species, of which almost 100 are marked *n. sp.* Of these, however, nearly one-fourth have been previously otherwise determined by such bryologists as Sullivant, Mitten, and Bescherelle. In view of these ratios we are inclined to think the finding of so many "crumbs" is due rather to the fineness of the crumb brush than to the carelessness of other sweepers.—C. R. B.

BELAJEFF'S account[22] of the origin of the cilia of spermatozoids has been confirmed and supplemented by Dr. W. R. Shaw,[23] who has taken Onoclea and Marsilea as his types. In these plants, as in Equisetum and Gymnogramme, the cilia arise from a small cytoplasmic body lying in the mother cell of the spermatozoid. For this cytoplasmic body, which was designated "Nebenkern" by Belajeff, Dr. Shaw proposes to adopt the more expressive name "blepharoplast," a name first employed by Webber to denote a similar structure in Zamia. Dr. Shaw has sought to discover the origin of the blepharoplasts and their behavior in karyokinesis. In the antheridia of Marsilea true blepharoplasts are found only in the last two cell generations. In the early stages nothing like a blepharoplast is present, but in the karyokinesis intervening between the two- and four-celled stage a small body appears at each pole of the two spindles; subsequently each of them divides into two. Since these bodies disappear into the cytoplasm and do not give rise directly to the true blepharoplasts, the author calls them "blepharoplastoids." About the time when the blepharoplastoids are lost sight of, the blepharoplasts make their first appearance as small granules situated in the spindle-poles of the nuclear figures which precede the eight-celled stage of the antheridium. Each of them divides into two. During the following resting condition of the nucleus these two halves gradually separate, at the same time increasing in size, and move round to the positions to be taken by the poles of the next following spindles. During the ensuing karyokinesis they remain practically unchanged. In the mother cell of the spermatozoid the blepharoplasts become granular, elongate, and probably undergo the same transformations which Belajeff has described in detail.

The accompanying diagram, copied from Dr. Shaw's paper, will help to make clear the relations of the blepharoplast as, well as to explain his substitution of the zoological terms "spermatocyte" and "spermatid" for the exceedingly cumbrous phraseology in use among botanists. While changes in terminology are difficult to secure, the advantages of the suggested modifications are obvious. Indeed it would be almost ludicrous to speak of "great-

[22] Berichte der deutschen bot. Gesell. **15**: 337–345. 1897, and **16**: 140–143. 1898.
[23] Berichte der deutschen bot. Gesell. **16**: 177–184. 1898.

grandmother cells," as would be necessary in describing the primary spermatocytes.



Naturally the question arises: Is there any relationship between blepharoplasts and centrosomes? The identity of the two structures was conjectured by Belajeff and is accepted by Ikeno; and certainly when one considers their similarity in staining reaction, position, size, and divisions, together with the analogies which animal spermatogenesis affords, it seems a not unreasonable conjecture to suppose the blepharoplast to be a centrosome modified for the performance of a new function. Such a view will probably be taken by those who share the opinions of Guignard and Schaffner, and by most animal cytologists. But those who hold with Strasburger and his assistants that there are no centrosomes among cormophytes will of course reject it. Neither Belajeff nor Shaw is prepared at present to maintain the homology of centrosome and blepharoplast. Dr. Shaw says: "At present we can only express the view that the blepharoplast is a kinoplasmic body set apart for the purpose of forming cilia."—WILSON R. SMITH.

SINCE THE ANNOUNCEMENT by Treub in 1891 of chalazogamy in Casuarina there has been on the part of morphologists a persistent interest in knowing just how far this process extends in fact and in meaning. It was for a time supposed that the phenomenon is shown by Casuarina only, and this was used as the basis of a new classification — the chalazogams represented by Casuarina, and the porogams represented by all other angiosperms. But

such ideas had to be abandoned when Miss Margaret Benson reported chalazogamy in Alnus, Corylus, Betula, and Carpinus. Later, Nawaschin announced that in *Juglans regia* the pollen tube takes an intercellular course within the ovule and agrees in a general way with the first reports of chalazogamy. Since Miss Benson's publication it was supposed that this peculiar condition was confined to the Casuarinaceæ, Betulaceæ, and Juglandaceæ, until, in Nawaschin's laboratory, the genera Urtica, Cannabis, Humulus, and Morus were found to have the pollen tube evading the micropyle and taking an intercellular course within the ovule, though not agreeing in details with the previous accounts of chalazogamy.

New evidence is now furnished by Nawaschin,[24] the plants studied being *Ulmus pedunculata* and *U. montana*. The writer indulges in a discussion of the nature and location of the influence which directs the growth of the pollen tube of the porogams. This influence may be entirely within the tube; or within a secretion produced by certain cells of the style and nucellus which attract and nourish the tube; or these cells of the style and nucellus may serve only as mechanical guides, while the real impulse to growth rests within the tube. It is now probable, however, that a combination of all these factors constitutes the directing influence. Such might furnish an explanation for the porogams but not for the chalazogams.

The behavior of the pollen tube of the elms is divided into three categories. The first is given as the normal behavior, in which the pollen tube passes down the funiculus of the anatropous ovule, which is suspended from the top of the carpel cavity. From the funiculus the tube passes across above the short outer integument and through the inner one, reaching the top of the nucellus, after which the regular behavior is observed. In the second category the tube may branch profusely and with no definiteness within the funiculus and the integument. This branching may occur out of the tissues after the pollen tube has reached the tip of the nucellus. In such cases the male cells within the tube always follow the newest branch. In the third category the tube grows down the funiculus near to the bases of the integuments, then grows up through the inner integument to a region on a level with the nucellus tip, when it turns across to the bottom of the micropyle as before. Or, instead of passing up between the cells of the inner integument, it may pass through the chalaza into the embryo sac as the tube of a true chalazogam.

In no case was any tissue found which could be considered especially conductive or nutritive tissue. Nawaschin thinks these two species represent a region in which these tissues are not yet definitely differentiated, but that the chalazogamic habit is being dropped as is evidenced by the varied attempts of the pollen tube to reach the tip of the nucellus, and by occasional reversion

[24] NAWASCHIN, SERGIUS: Ueber das Verhalten des Pollenschlauches bei der Ulme. Bull. d. l'Acad. Imper. d. Sci. d. St. Petersbourg **8**: 345. 1898.

to passage through the chalaza. He would look upon the elms as one of the transition types from the chalazogams to the porogams.

Supplementing this work of Nawaschin, N. Zinger has found[25] that in the ovules of Cannabineæ the inner integument, which is elsewhere very delicate, over the apex of the nucellus becomes massive and is completely coalescent with the thick outer integument. The micropylar canal before fertilization is entirely closed by papillary outgrowths from the surface and marginal cells of the integuments. These outgrowths form a densely interwoven firm tissue above the apex of the nucellus, passing into the tissue of the ovary wall above. The pollen tube follows the central cells of the styles (conducting tissue ?) downwards, passes along the upper wall of the ovary, penetrates the outer and inner integuments or bores through the tissue filling the micropyle, and reaches finally the nucellus. Here it produces numerous sac-like tumid branches about the apex, until one very delicate tube penetrates to the embryo-sac.— OTIS W. CALDWELL.

A RECENT MONOGRAPHIC work by Adamovic on the vegetation formations of eastern Servia adds greatly to our knowledge of the flora of that country.[26] Botanical research in Servia is a matter of the last two decades, because of the blighting rule of the Turkish government. The names of Pancic and Petrovic are about the only ones that need to be recollected, with the exception of that of the author of the monograph under review.

Servia is a mountainous country in the truest sense, even the river valleys being some hundreds of meters above sea level. The mountains belong to the Balkan and Rhodope systems and are of various geological ages from Precambrian to Recent. The country is drained by the Morava and Timok rivers, tributaries of the Danube. The climate is intermediate between that of continental Europe and the Mediterranean climate to the south.

The author first discusses the formations of the plains and lower hills. There are extensive rocky pastures, mostly along the slopes of hills; the floral covering is sparse and the plants are decidedly xerophilous in structure and periodic in their life functions. These rocky pastures grade into hilly steppes, where the soil is more gravelly or sandy than rocky. In both of these formations euphorbias are characteristic. The meadows are divided into valley or true meadows and swampy meadows, the latter grading into swamps. Rock formations are quite abundant and closely related to rocky pastures, though the rocks are larger and the vegetation more open. The northern slopes have a richer flora because of greater moisture. The swamp and water formations do not form a very large part of the flora of the country. Among the shrub and tree formations there are extensive areas of brushwood;

[25] Flora **85**: 189–253. 1898.

[26] ADAMOVIC, LUJO.— Die Vegetationsformationen Ostserbiens. Engler's Bot. Jahrb. **26**: 124–218. 1898.

along streams are thickets with a dominance of willows; the only formations with tall trees are the poplar forests. The influence of man on the flora of the plains and hills has been very great, especially in the destruction of forests.

On the mountains below the timber line mountain meadows are found quite commonly. In the calcareous regions there are peculiar funnel-shaped depressions formed by the erosion of the limestone. These depressions are called *Dolinen*, and their flora is more or less xerophytic. The rock formations of course are well developed, and the author divides them into calcareous and eugeogenous, the latter with a much richer plant covering. (The term eugeogenous was introduced years ago by Thurmann; it means easily decomposed into good soil.) There are low forest thickets (*Buschwald*) in very many places, representing a second growth. There are two true forest types, the oak forests and the subalpine forests with a dominance of beeches.

Above the timber line there are subalpine meadows, heaths and thickets. Higher up are alpine mats and extensive lithophytic formations. The influence of man becomes less and less evident as the altitude increases. The last chapter gives a short summary of the most important results. Adamovic subdivides eastern Servia into four altitudinous regions based on barometric measurements. (1) The regions of plains and hills reaches up to 600^{m}, and is characterized by the almost entire absence of forests, a condition wholly due to the influence of man. The areas once wooded are occupied by culture plants, mainly cereals, hemp, tobacco, and melons. The hillsides are covered by vineyards and fruit trees. The vegetation belongs to Drude's Pontic type, mixed with some Mediterranean elements. The average annual temperature is 11.5°C., and the vegetation period is ten months. (2) The mountain region extends from 600^{m} up to 1100^{m}. Culture formations are much less abundant, the Mediterranean floral elements have disappeared, the Pontic elements are less abundant, and the characteristic vegetation of central Europe is preeminent. The low second growth timber is the most common formation. The mean temperature is 9.5°C. and the vegetation period nine months. (3) The subalpine region extends between 1100^{m} and 1660^{m}. The beech forests have replaced the oak and the second growth. The heaths and subalpine meadows are also prominent. The floral elements coincide mainly with the mountain zone of central Europe. The average temperature is from 7° to 8°C. and the growing period less than eight months. (4) The alpine region has no culture formations and the dominant landscape features are given by rocks and the variegated alpine mats. The floral elements are a mixture of the alpine types of central Europe and endemic types. The mean temperature is about 6°C. and the vegetation period scarcely six months.—HENRY C. COWLES.

M. CH. DASSONVILLE has made an elaborate study of the effect of mineral salts upon plant structure.[27] A great number of experiments were made, in which direct control was had by germinating in solutions, while supplementary evidence was gained by germination in soil to which either solutions of a single salt of graded strengths were presented, or complex solutions accompanied by check experiments in which the salt under study was omitted from the complex solution presented. Check experiments in distilled water accompanied those in which germination was effected in a liquid solution. Certain mineral solutions induced more vigorous growth of both vegetative and floral parts, but a period of life no longer than in aqua pura. M. Dassonville presents also the surprising results that cutinization, sclerification, and lignification are much more accentuated in young plants in distilled water than those of the same age in mineral solutions. The observations are not directed so much to general effects as to the most intimate histological alterations. One comprehends that the work must be most extensive to present reliable results.

The effect of particular salts may be summarized as follows: magnesium sulfate retards normal development only at first, later becoming indispensable for it. In the castor-oil plant the retarding effect is chiefly upon the terminal root, which is atrophied. Later adventitious roots develop, the more the stronger the solution. In hemp there is no adventitious development, but the secondary wood is stimulated and the primary vessels retarded.

Potassium phosphate is necessary at all stages. Its absence insured a characteristic abnormal development of the roots. Its presence stimulates the sclerification of the pericycle.

Potassium silicate deepens the green of the leaves and affects their structure and lignifies the peripheral cells of the root tip.

The effect of nitrates varies in different plants, and with the strength of the solution and the stage of development. No attempt was made to formulate a general law from the confusing results of the seven types studied. However, the acetates of ammonia and potassium seem best for hemp and buckwheat, while sodium acetate is deleterious. No matter what the base, the acetates call forth a special tint in the leaves, which the author attributes especially to acetic acid.

Potassium stimulates growth, but retards the differentiation of sclerenchyma, and may thus increase the liability of "lodging" in the Gramineæ. Sodium is less favorable to growth, but hastens lignification of the stem-base, preventing "lodging."

Calcium chloride and magnesium seem equally beneficent to hemp and buckwheat, and the decreasing order of utility of acids for these types is acetic, phosphoric, hydrochloric.

[27] Influence des sels minéraux sur la forme et la structure des végétaux. Revue générale de Botanique **10**: 15 sqq. 1898.

The author argues that the absence of high nutrition, *i. e.*, germination in distilled water, induces the seedling to direct its energy chiefly to cell differentiation. And, vice versa, it is to be expected, and his results demonstrate, that a seedling grown in a rich nutrient medium, such as Knop's solution, will multiply cells rapidly without differentiation. In other words, sterile soil predicates precocious sclerification; rich soil a later appearance of the ultimate structure, but a more rapid division of cells without differentiation. Apparent counter evidence is offered by the effect of single salts, which stimulate the differentiation of particular regions, as the effect of potassium phosphate on the pericycle or of magnesium sulfate on the vessels of the root. M. Dassonville evades a contradiction of results, asserting the latter to be a differentiation of a particular region called upon to play a definite rôle by the abundance of particular substance, and holding that, for the rest, the meristem reserves as long as possible the expenditure of energy in the way of differentiation. The author seriously questions the taxonomic value of anatomical characters, a challenge which, with the trend wholly in the direction of phylogenetic characters as the ultimate basis of classification, will find few takers. Such specific distinctions are altogether too cumbrous for taxonomic purposes.

The value of these results is apparent and we recognize the great difficulties surmounted in their attainment. The deductions, however, are by no means final, because there is too little accord among even the few types studied. Results obtained from the investigation of lupine, wheat, oats, morning glory, egg plant, tomato, and pine, do not permit the induction of general laws. Though the methods show the work to have been stupendous, we are impressed with the impossibility of eliminating disturbing factors aside from the one under consideration. For example, the author concludes that the optimum of potassium phosphate "augments only the quantity of water in the plant," a result obtained from buckwheat. But, he adds, "sometimes the amount of dry matter is increased. It is so in hemp."—JOHN GAYLORD COULTER.

NEWS.

M. CAMILLE SAUVAGEAU has been appointed professor of botany in the University of Dijon.

WE NOTE the recent death of Professor Joseph Gibelli, professor of botany at the University of Turin.

DR. DOMENICO SACCARDO has been called to Bologna as the assistant of Professor Fausto Morini in the botanical garden of the university.

THE distinguished phycologist, J. B. Edouard Bornet, of Paris, celebrated his seventieth birthday on the second of September last.

THE SECOND annual meeting of the Society for Plant Morphology and Physiology will be held at Columbia University, Wednesday to Friday, December 28 to 30.

PROFESSOR DR. C. SCHRÖTER, of Zürich, began about the last of August a tour of the world, intending to visit North America, Japan, China, Java, Sumatra, India, and Egypt.

ACCORDING to the newspapers Professor Dr. Oscar Brefeld of Münster has accepted the call to the University of Breslau as successor to the late Dr. Ferdinand Cohn.—*Bot. Zeit.*

DR. G. VENTURI, the well-known Austrian bryologist, died on the fifth of June. His moss herbarium, containing about 4000 species, and his library were bequeathed to the city of Trent.

DR. ERNST BAUER (Smichow bei Prag, N. C. 961) has begun the issue of a set of exsiccati, entitled *Bryotheca Bohemica*. In the issue of Century I Dr. V. Schiffner and other less known bryologists have cooperated with Dr. Bauer. The price per century is *M* 14.

FROM the *Forester* we learn that the New York College of Forestry has about thirty-five students taking advantage of its courses. Only two are regularly matriculated in the college, the rest being students of engineering who registered in College of Agriculture to escape fees, intending to change over to the College of Forestry later.

DR. CARL FREIHERR VON TUBEUF, private docent in the university and the technological school of Munich and director of the Bavarian station for plant protection and plant diseases, has been given permission by the government to take a staff position in the biological experiment station for agriculture and forestry connected with the imperial bureau of hygiene at Berlin. He will direct the botanical laboratory.

PROFESSOR DR. G. LEIMBACH, the editor of the *Deutsche botanische Monatsschrift*, announces that, at the end of the year, the journal again comes into his possession as publisher. It will be published as heretofore at *M* 6 per year. The office of publication is at Arnstadt, Thüringia.

THE *Deutsche botanische Monatsschrift* announces in its October number (received late in November) that a most annoying delay has occurred in the issue of the Ascherson-Gräbner *Synopsis* of the flora of central Europe. No explanation is given, but the *Monatsschrift* is authorized to say that, at all events, no additional part is to be issued this year.

MR. W. T. SWINGLE has been commissioned by the United States Department of Agriculture to investigate the agriculture of the countries in Europe, Asia, and Africa which border on the Mediterranean. He is to study the plants cultivated and the methods of culture, in the hope of discovering plants which may be introduced to advantage into America. The work is to be done under Mr. Fairchild's section of seed and plant introduction, and will occupy about six months, after which Mr. Swingle will return to America. During his absence letters may be addressed in care of Thomas Cook & Son, Ludgate Circus, London, E. C.

MR. D. G. FAIRCHILD, formerly special agent in charge of the section of seed and plant introduction, U. S. Department of Agriculture, has been assigned, at his own request, to duty as an agricultural explorer. He will visit both coasts of South America, in company with Mr. Barbour Lathrop, of Chicago, to investigate the economic plants of those regions and import stock of the more promising sorts into the United States. Mr. O. F. Cook, formerly Liberian agent of the New York Colonization Society and director of the college and the coffee experiment farm near Monrovia, has been appointed to take charge of the seed and plant introduction work, under the direction of the botanist of the department.

DR. C. F. MILLSPAUGH, of the Field Columbian Museum, is to leave New York about December 20 for the West Indies, where he will spend the winter months in botanical exploration. He is a guest upon the private yacht of Mr. Allison Armour, which will be largely under his direction as to the ports visited. Ample arrangements have been made for rapid and complete collecting, the purpose being not to obtain duplicates, but to secure as complete a representation of the flora as possible. Mr. E. P. Allen, the photographer of the museum, will also accompany the expedition, and will pay special attention to the general ecological features.

The places to be visited are as follows: San Juan de Puerto Rico; San Domingo; Santiago de Cuba; islands of Grand Cayman, Little Cayman, and Cayman Brac; Isle of Pines; Cape Corientes; islands of Cozumel, Mugeres and Holbox; interior of Yucatan as far as Buena Vista Xbac and Chichea Itza; the Alacran Shoals; and Havana.

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